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DECEMBER, 1940
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Vol. XLIV.

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The Journal of The Royal Aeronautical Society

With which is incorporated The Institution of Aeronautical Engineers

Edited for the Council by Capt. J. LAURENCE PRITCHARD, Hon. Fellow

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Review

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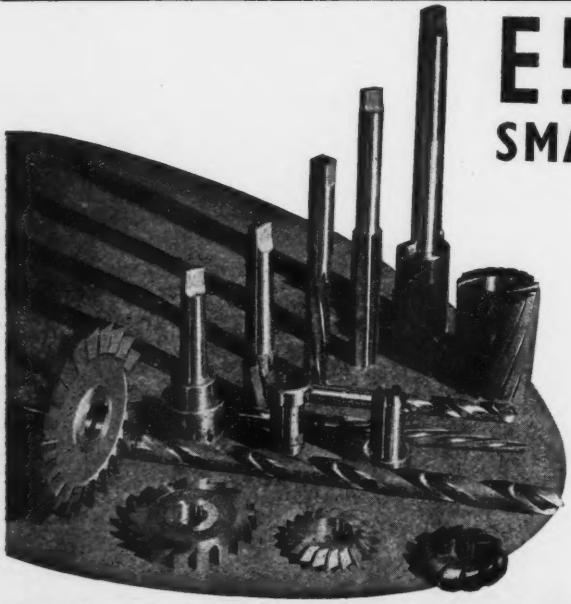

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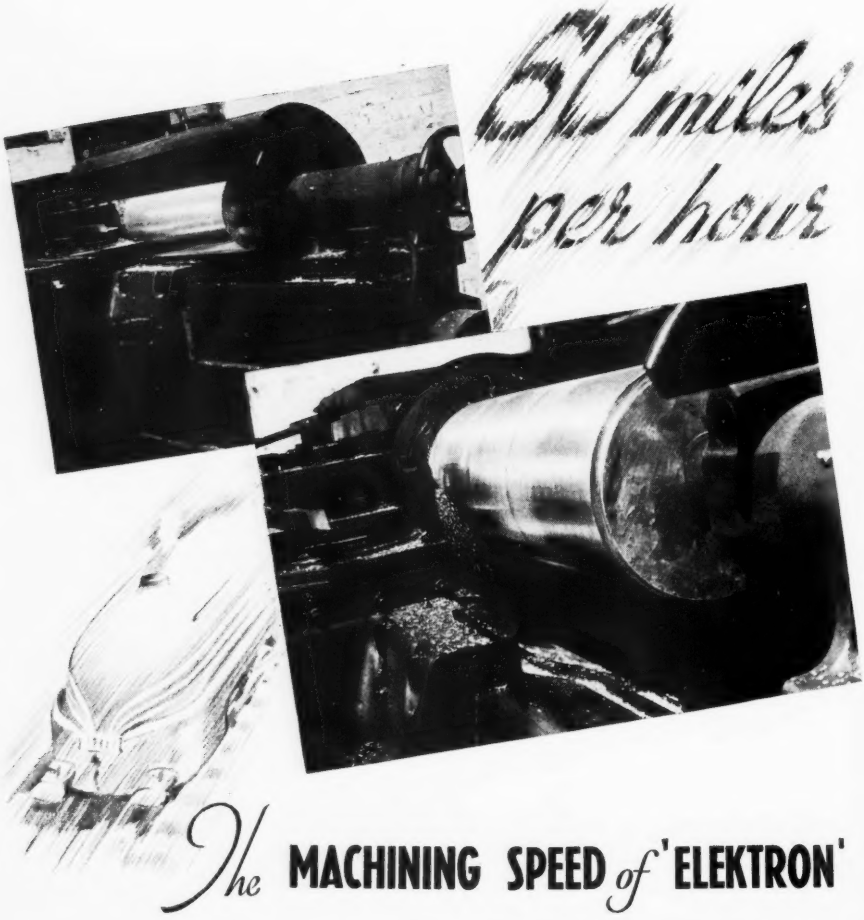

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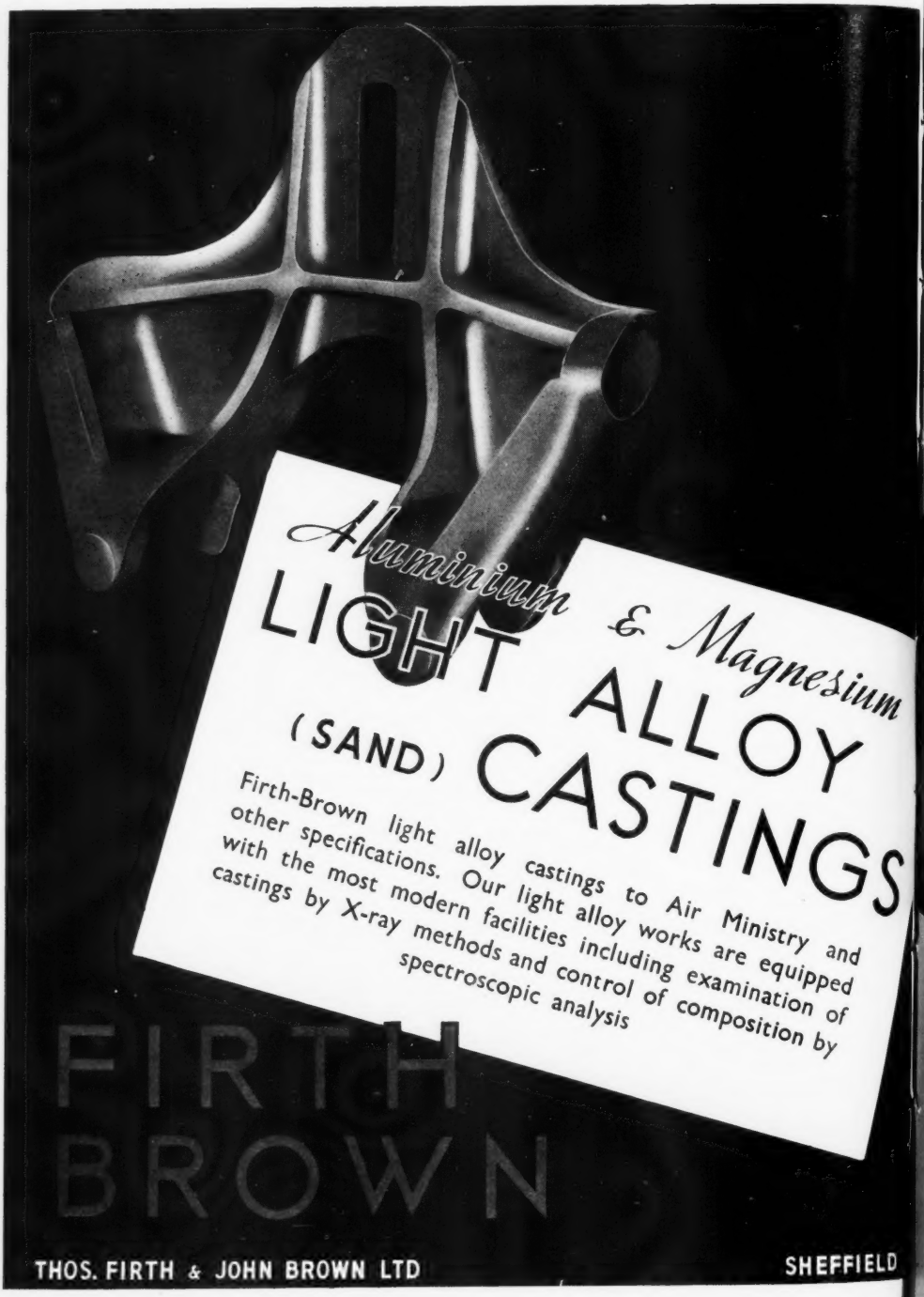
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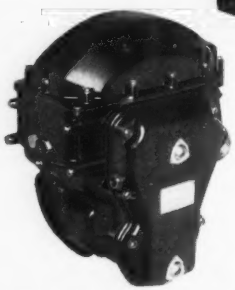

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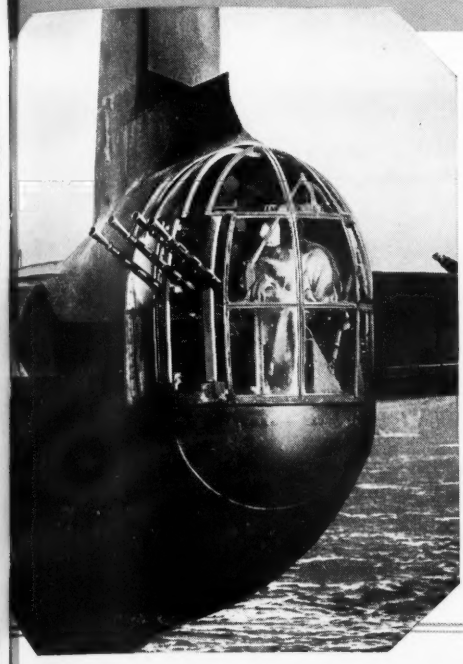

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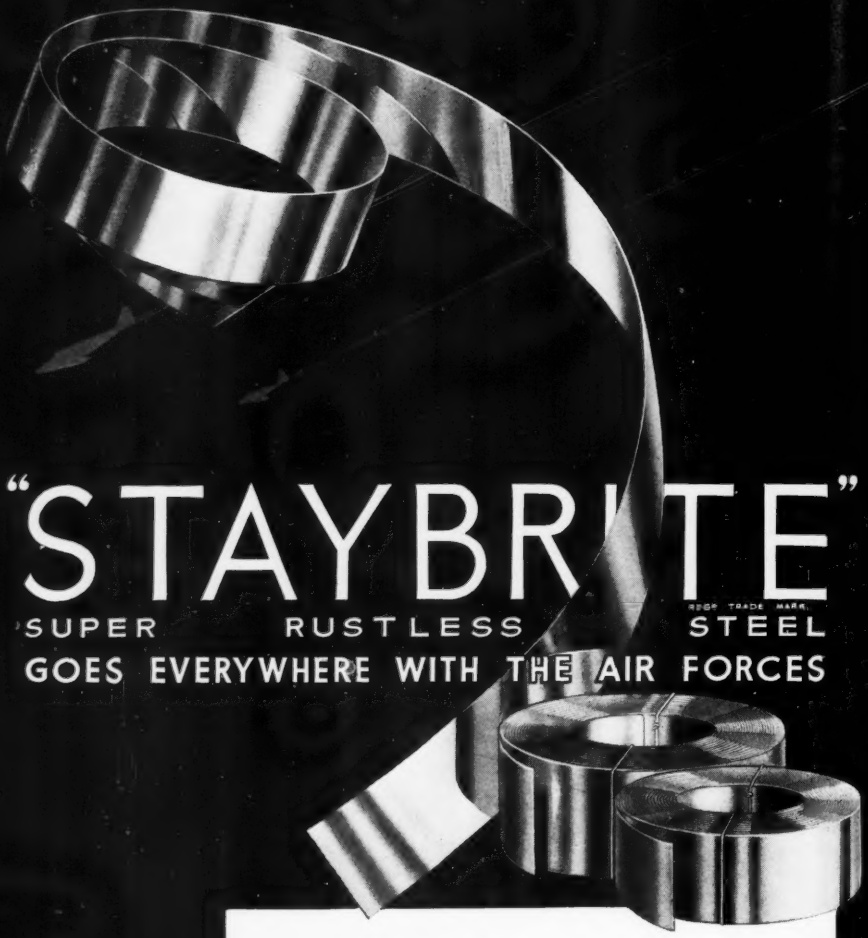

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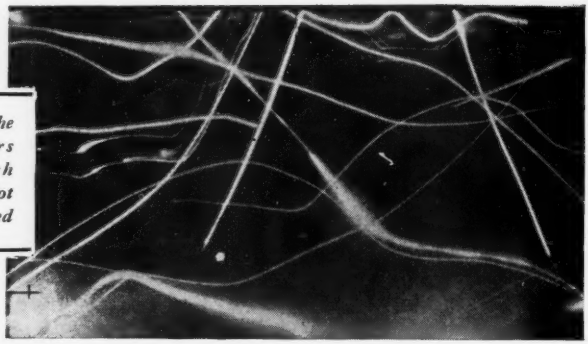
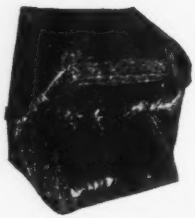


Any bullets shown by these tracks, perforating a part of the oil petrol lay-out of an air craft, can induce an outbreak of fire.



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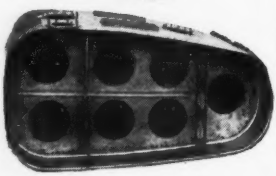

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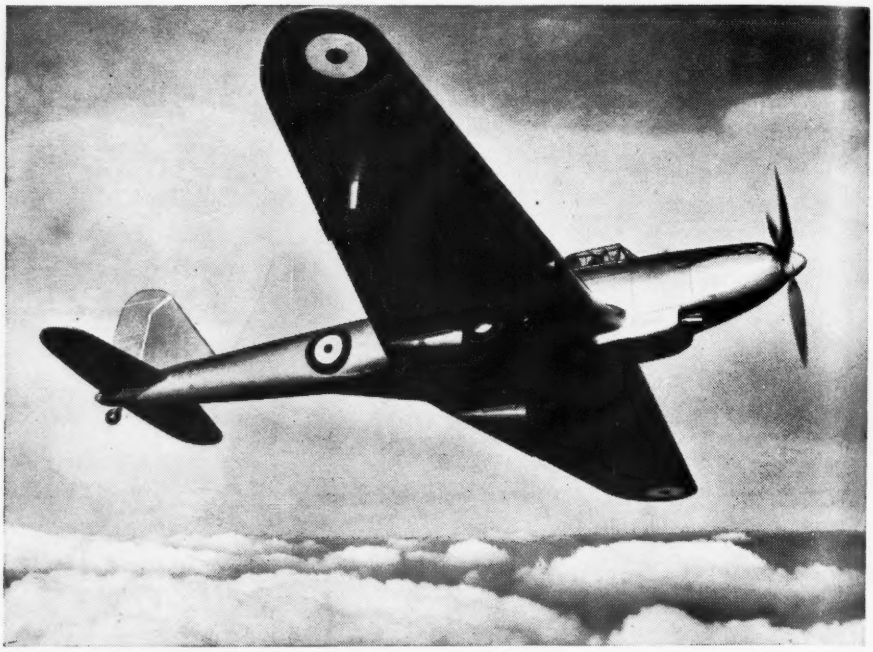

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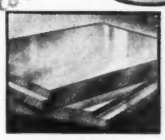

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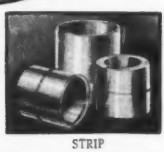

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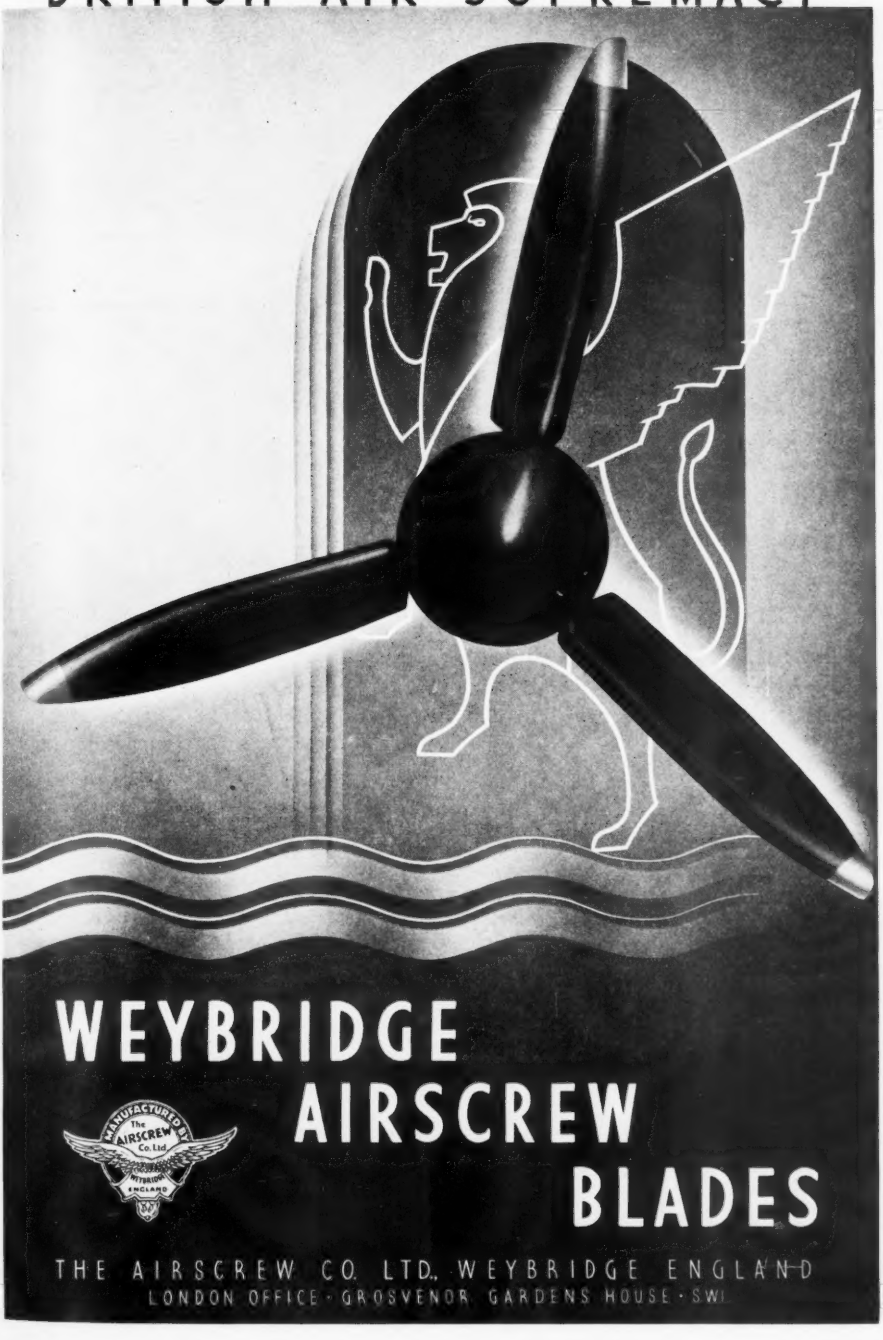
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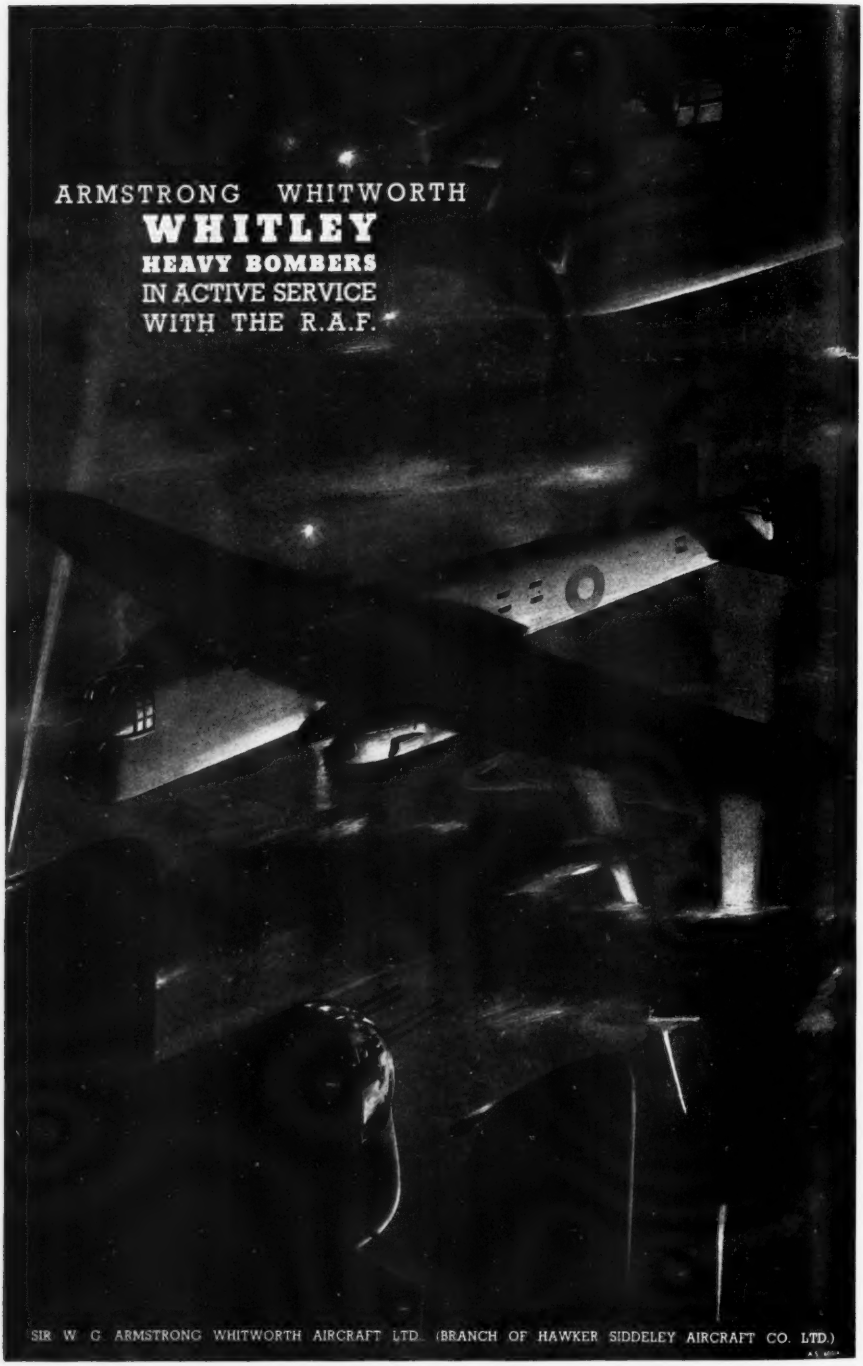
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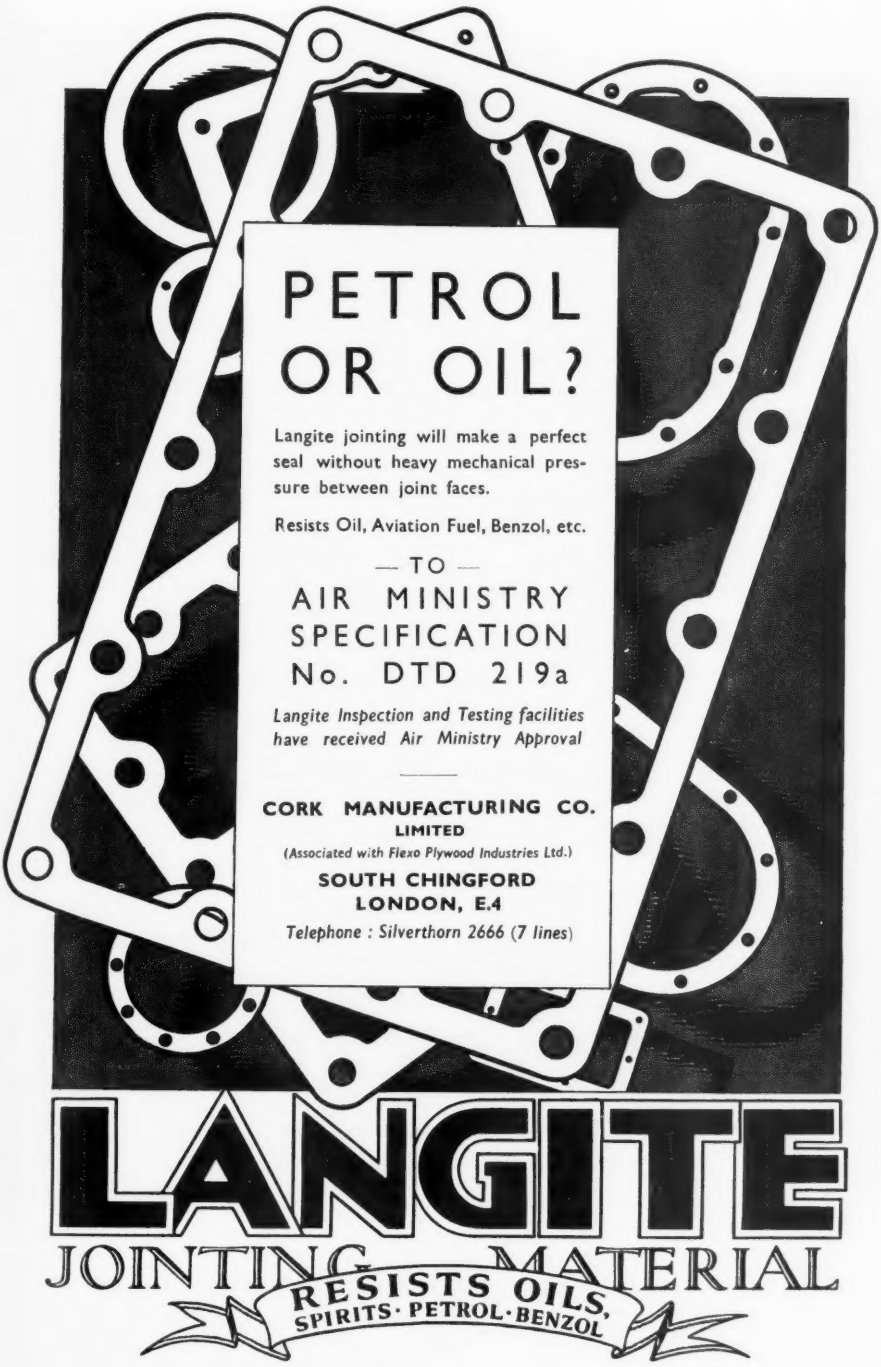
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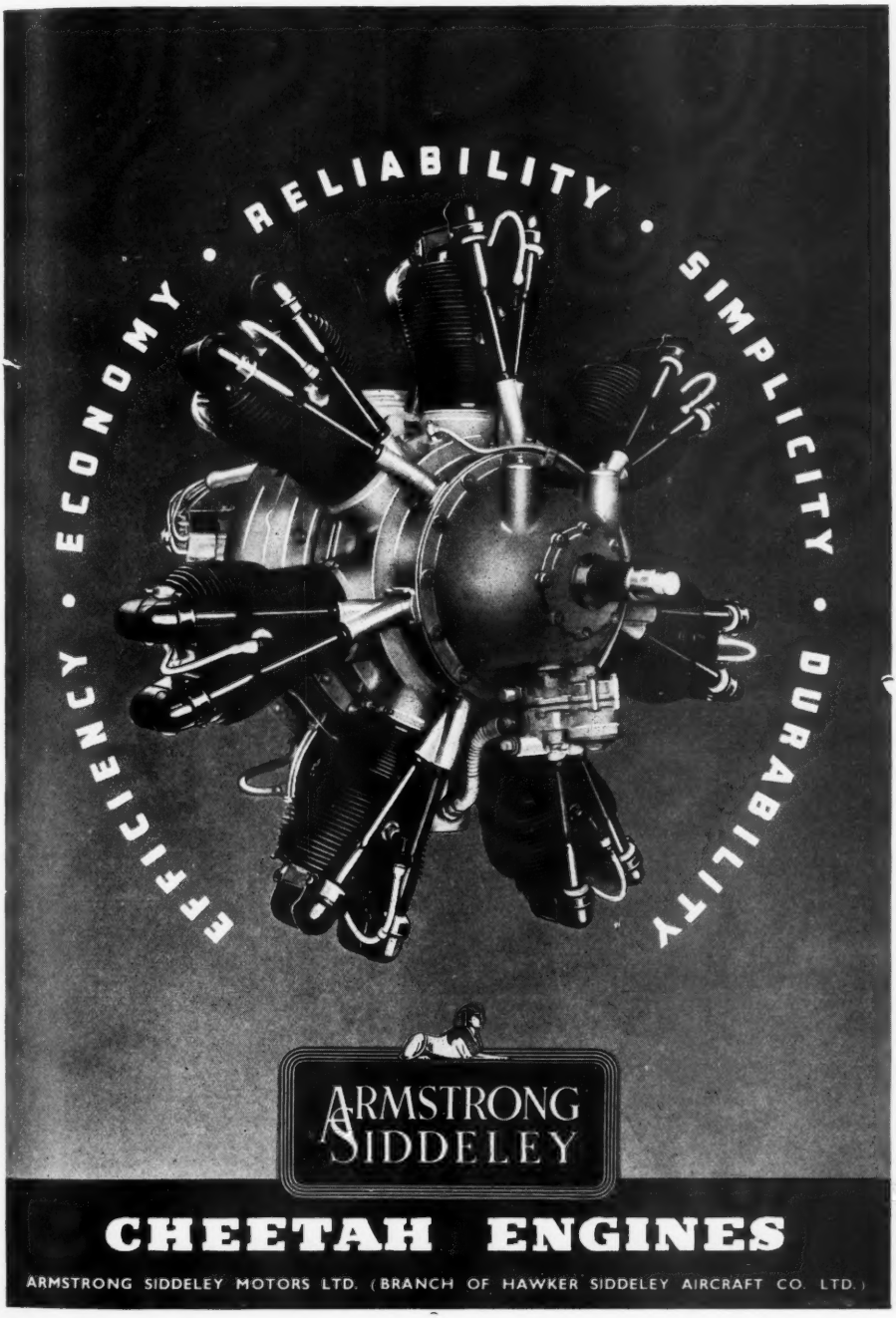
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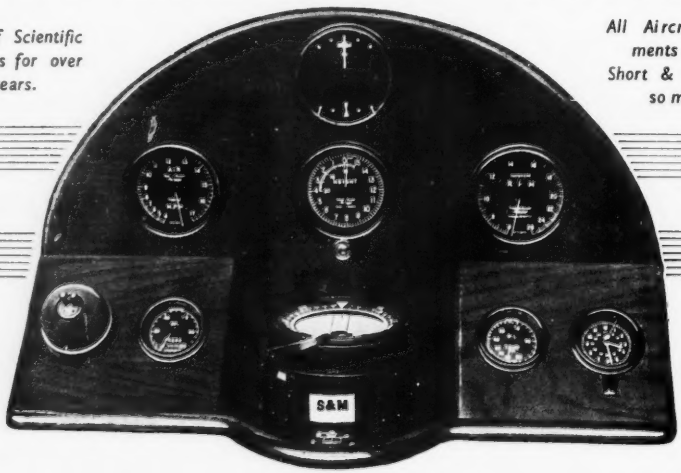

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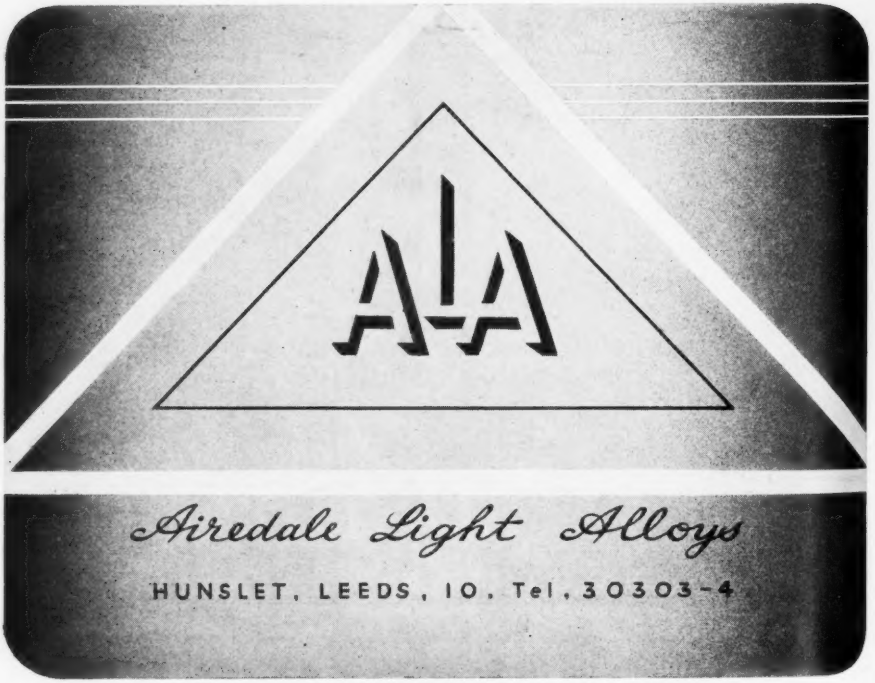
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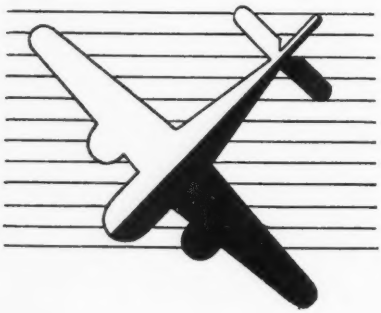

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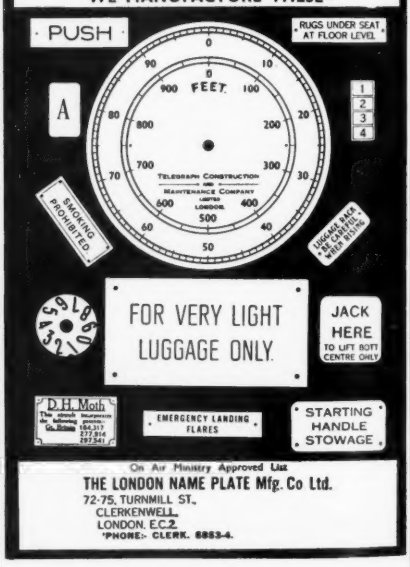

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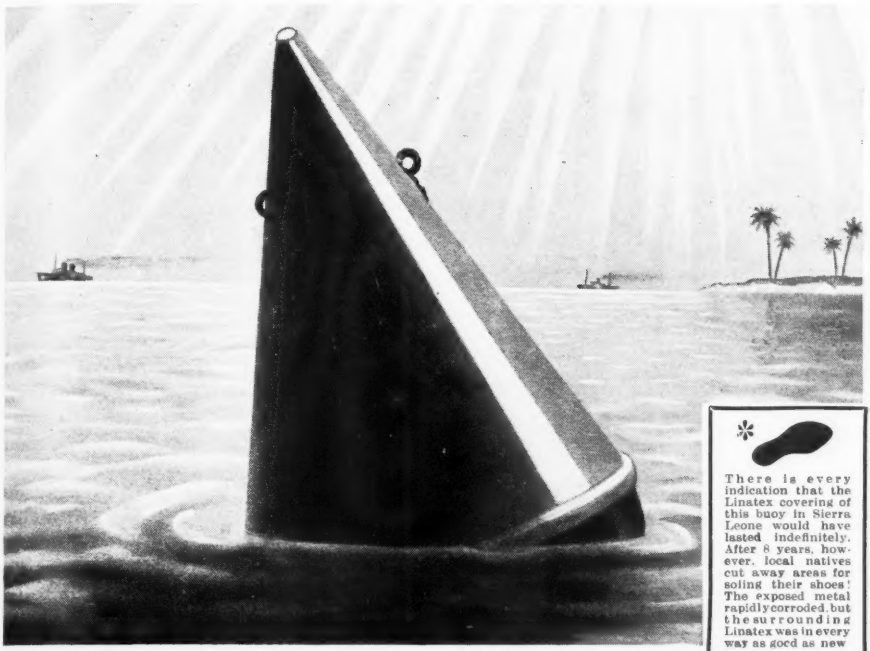

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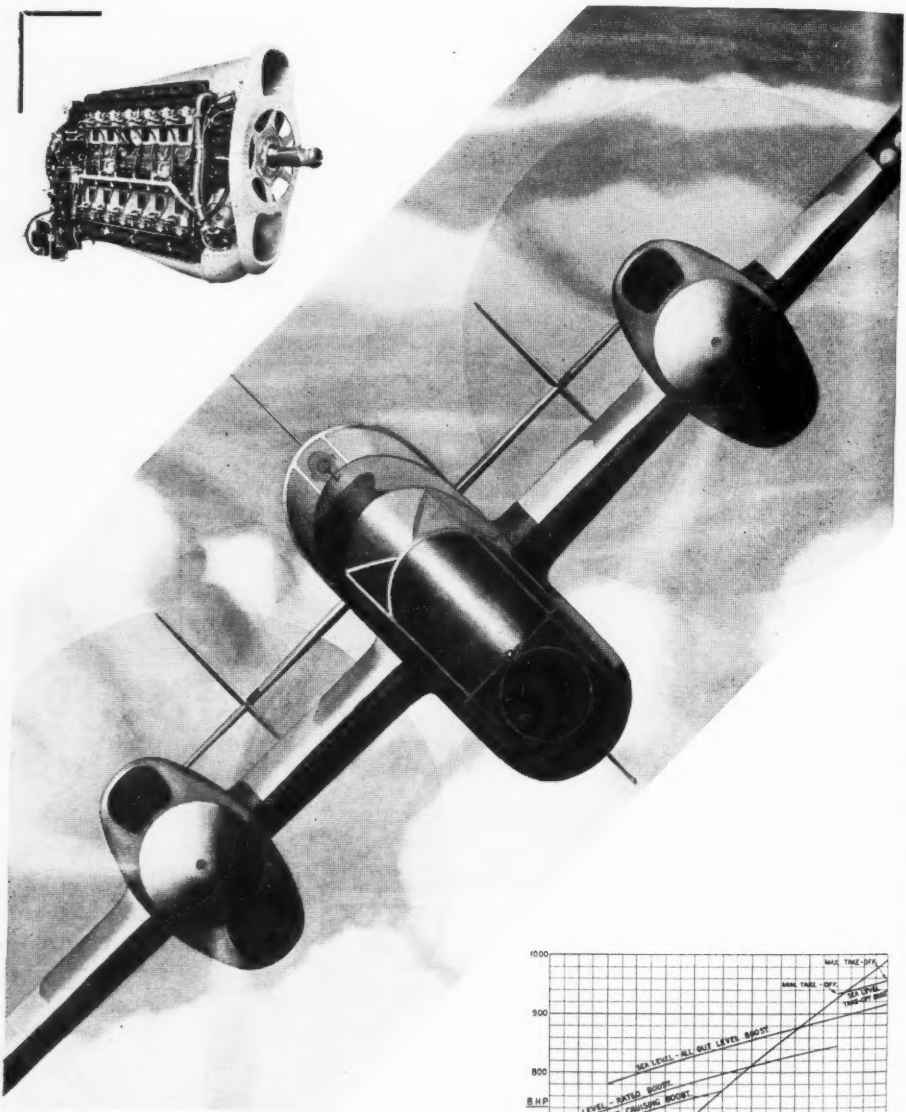

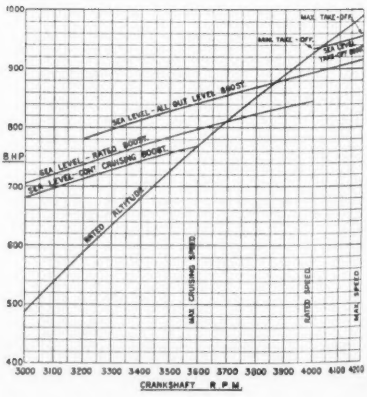

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THE ROYAL AERONAUTICAL SOCIETY
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THE JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY *was founded in* 1897 *in succession to the* ANNUAL REPORTS.

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MONTHLY NOTICES,

DECEMBER, 1940.

Christmas Holidays.

The Offices of the Society will be closed on Wednesday, December 25th, 1940, and Thursday, December 26th, 1940.

Major D. H. Kennedy.

It is with the deepest regret that the Council record the sudden death on November 19th, 1940, of the Honorary Treasurer, Major D. H. Kennedy. Major Kennedy had been the Honorary Treasurer of the Society for over fourteen years and for many years was chairman of the Finance Committee. He was largely responsible for steering the Society through a very difficult financial period, and he lived to see the Society for which he had worked so long and so wholeheartedly housed in surroundings fitting to its importance.

Associate Fellowship Examinations.

The next Associate Fellowship examinations will be held in the offices of the Society on the mornings of December 10th, 11th and 12th, 1940. The Library will be closed on those days.

Society's Emergency Address.

It should be made clear that although the Society has published from time to time in the Journal its emergency address and telephone number (which can be used at any time alternatively with those of the Society), the Society functions, and has functioned from the beginning of the war, from No. 4, Hamilton Place, W.1. It will continue to function from London as far as possible, even though some of the staff may have to be moved, others will continue in London itself. It is obvious that events may make things difficult and cause a certain amount of delay, and members are asked to bear these events in mind.

The emergency address is—

Brook House,
Old School Lane,
Brockham, Surrey.

Telephone: Betchworth 189.

Election of Members.

The following members were recently elected:—

Associate Fellows.—Frederick Thomas Meacock (from Student).

Associates.—William Kenneth Austin (from Student), Robert Henry William Beer, John William Dobson, Leslie Thomas Ellis, Thomas Edward Laws, Cyril Bertram Shore, William Henry Syddall.

Graduates.—Peter George Gradwick Knight (from Student), John Poole.

Students.—Dennis Frederick Barnes, Peter Wright Brooks, Kenneth Lewis Hodkinson, Gwynfer Rowland Hopkins, Robert Guy Huggett, Stanley Croft Johnson, Geoffrey Ratcliffe, Joan Robinson, Dennis John Somper, John Frederick Butler Welch.

Indexes.

In this issue appear the indexes of the Journal. The indexes for the Abstracts from the Scientific and Technical Press are separate. From July to December the Abstracts have been published as a separate section at the end of the Journal and are now provided with a separate index, so that they may be bound apart from the Journal. In future the Abstracts will be published in this way, so that annual volumes may be bound separately, if desired.

Corrections.

In the paper on "A Family of Aerofoils with Rounded Trailing Edge," by J. C. Cooke, published in the Journal for October, 1940, the reference on page 774 should read "(2) Piercy, Piper and Whitehead, Aircraft Engineering, Vol. X (1938), pp. 339-343."

In the paper "On the Calculation of the Boundary Layer," by L. Prandtl, published in the Journal for November, 1940, in the equations on page 799 αz should read $a\alpha$ and the $\sqrt{}$ sign is missing from the argument of the Bessel function in the first term of the second equation.

J. LAURENCE PRITCHARD, *Secretary and Editor.*

ANALYSIS OF A RIGID-JOINTED FRAMEWORK.

By E. H. Lewitt, B.Sc., Ph.D., A.M.I.Mech.E.

Introduction.

In the design of structural frames it is often the practice to assume the joints to be pinned, or hinged, and to calculate the forces in the members on this assumption; actually, the joints are made with considerable rigidity. The following are the results of an analytical and experimental investigation into the stresses in a rigid-jointed space frame and of the magnitude of the errors due to the assumption of pinned joints.*

The investigation may be divided into the following sections:—

(1) An analytical solution of the problem based on a method of successive approximations.

(2) An experimental method of obtaining the bending moments in the members by measurement of skin stress.

(3) An experimental method of obtaining the bending moment in the members by measurement of slopes.

(4) A comparison of the results with those obtained from an identical structure fitted with pinned joints.

On the suggestion of Professor A. J. S. Pippard, a space-framed structural model was used for the investigation which was identical with a previous model made by him, with the exception of the joints. Pippard's model was a fully braced hexagonal tube having pin-joints, which was tested by him and Professor J. F. Baker; the results of these tests are given in R. and M. 948, Experiment No. 4. The present model was constructed of identical material and was of the same dimensions, but the joints consisted of malleable iron castings and were rigid. The use of a model otherwise identical with that of Pippard's enables a comparison to be made with the two independent sets of results.

Another advantage of using a model identical with Pippard's is the fact that an exact analytical solution of this type of structure has been evolved by Professor R. V. Southwell.† Southwell's solution has been applied by Miss L. Chitty to the pin-jointed model of Pippard;‡ the results obtained by Miss Chitty enable a comparison to be made between the theoretical and experimental results.

2. Description of Model.

A photograph of the model is shown in Fig. 1. It consisted of a hexagonal frame built up of longitudinal and transverse members braced together with steel wires; the whole was rigidly fixed to the wall at one end and suspended as a cantilever. The model consisted of three bays 30 inches long; a bay being the space between two consecutive transverse frames. The transverse frames were hexagonal in shape, having sides 25 inches long. The transverse frames were rigidly connected together by six continuous longitudinal members, one at each angle of the hexagon.

---

* The work was carried out in the Mechanical Engineering Department of the Imperial College of Science and Technology, South Kensington.

† Proc. Roy. Soc. A., Vol. 139, 1933. "On the Calculation of Stresses in Braced Frameworks," by R. V. Southwell, F.R.S.

‡ R. & M. No. 1528. "Determination of the Stresses in Braced Framework," by L. Chitty, A.F.R.Ae.S.

The transverse frame members and the longitudinals consisted of $\frac{7}{8}$ in. diameter steel tubing of 22 gauge. The rectangular area having its boundaries formed by two transverse members and two longitudinal members is known as panel. Each panel was diagonally braced in both directions by 4 B.A. steel wire, known as diagonals.

The transverse frames are radially braced by 4 B.A. steel wires known as radial members. These radial members were connected together at the centre of the hexagonal frame by means of a steel plate. Six radial members were fitted to each frame, one to each angle of the hexagon.

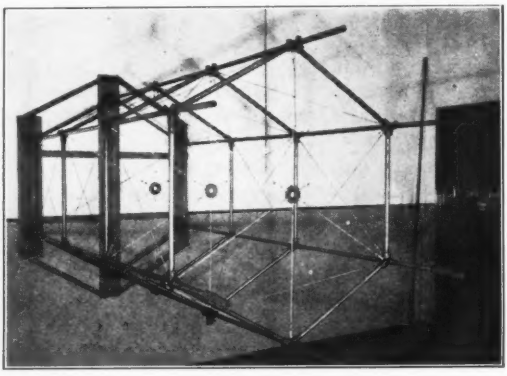


FIG. 1.

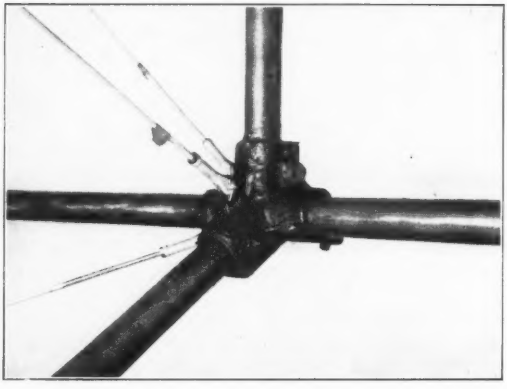


FIG. 2.

The joint between the transverse tubes and longitudinal tubes consisted of a malleable iron casting (Fig. 2). The longitudinal tube was continuous and passed through two arms of the castings as shown. The walls of these arms were split and could be drawn together by screws, which were tightened when the longitudinal was in position. The transverse tubes were fitted into the other arms of the casting and braced in position.

The joint casting had five lugs at the correct angles which were drilled for the four diagonal and one radial wire. These wires were connected to the lugs by forks and pins.

Turnbuckles were fitted to each wire, which were tightened so that the initial tension produced was greater than the largest force caused by the load. This ensured that each wire was capable of taking compression, because the largest compressive force placed in the wire by the loading of the model was not sufficient to overcome the initial tension placed in the wire by the turnbuckles.

The model was, at first, loaded by 50 lb. slotted weights placed on a carrier fixed to the free end. The carrier was supported by a knife edge so that it was free to swing in a transverse direction but not in a longitudinal direction. This ensured that the weight was evenly distributed to each side of the model, but, owing to the slots in the weights, a slight eccentricity was caused in a longitudinal direction. On account of this eccentricity, the method of loading was changed to a screw and ratchet device acting on a 400 lb. spring balance which read to the nearest 1 lb. Any torque was prevented by vertical guides. This loading device can be seen in the photograph of Fig. 5.

The model was loaded by 50 lb. weights up to a maximum load of 400 lbs. The stresses in the members were measured after the addition of each 100 lbs., both in loading and unloading.

The method followed for denoting any particular member of the structure is based on the numbering and lettering of Fig. 3. Starting from the fixed end

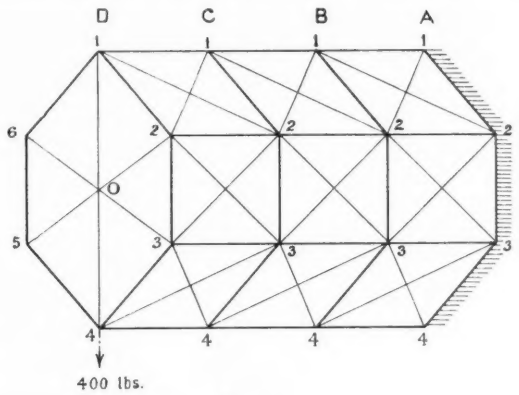


FIG. 3.

the transverse frames are denoted by A, B, C, and D; the corresponding bays being AB, BC, and CD. The longitudinals are numbered 1, 2, 3, 4, 5, and 6, commencing at the top, hence the longitudinals of Bay CD will be C_1D_1, C_2D_2, etc. The transverse members of Frame D will be 1.2, 2.3, etc.; the radial members will be denoted by 0.1, 0.2, 0.3, etc. The diagonal wires of Bay CD are denoted by ${}_1T_2$, ${}_2T_3$, etc.

The steel tubes used were made to B.E.S.A. specification T.10, and the wires were 4 B.A. Swaged Rods made to B.E.S.A. specification W.8.

(3) ANALYTICAL SOLUTION BY A METHOD OF SUCCESSIVE APPROXIMATIONS.

The structure was first assumed to be pin-jointed and the solution was obtained by assuming distortion to take place in the three perpendicular planes, namely, a vertical distortion, a longitudinal distortion and a transverse distortion. On the first application of the method, small quantities were ignored, but their effect was included as the successive approximations were applied. As the solution proceeded, the effect of the rigid joints was also included.

A relative vertical displacement between adjacent bays, due to the application of the 400 lb. load, was first assumed and the forces in the diagonal members due to this movement were calculated.

The effect of the longitudinal component of these diagonal member forces was next calculated. The forces in the diagonal members were then modified to allow for this longitudinal distortion.

The transverse distortion of the structure due to the radial components of the forces in the diagonal members was next taken into account.

The application of each perpendicular distortion affected the previous results obtained. On each successive application of the method, it was found that the difference of the results obtained, when compared with the preceding results, became smaller; the calculated forces were thus tending to stabilise. The method was repeated successively until the forces and displacements were stabilised, after which it was found that further applications of the method produced no appreciable change.

The solution consisted of the application of the following five operations, applied in the order given.

OPERATION 1.

A vertical displacement of each transverse frame, due to a shear force of 400 lbs. was assumed to occur across each bay; this is taken partly by the diagonal members as an axial force and partly by the longitudinals in bending. The amount taken by each will be in proportion to their relative stiffness.

From this assumed displacement the forces in the diagonal members and the deflection of each bay were calculated.

OPERATION 2.

The results of Operation 1 were next corrected for a longitudinal displacement of the joints. The forces in the longitudinal members were calculated from the horizontal components of the forces in the diagonal members, obtained from Operation 1. From these longitudinal forces the longitudinal displacement of the joints were calculated. The forces in the diagonal members were then corrected to allow for these longitudinal displacements.

New longitudinal forces were next calculated from the corrected diagonal member forces which, in turn, gave more exact longitudinal displacements. This process was repeated until there was no further change produced in the forces and displacements by its application. Thus, the correct forces in the diagonal members and the corresponding forces in the longitudinals, due to vertical and longitudinal displacement of the structure, were obtained by applying these successive approximations until the forces were stabilised.

OPERATION 3.

A transverse distortion of the structure was next assumed from the results obtained by Operation 2. Using the diagonal member forces so obtained, the following operations were performed:—

(*a*) The vertical and transverse horizontal forces at the joints of the transverse frames were calculated from the forces in the diagonal members. The shear in the longitudinal was calculated from the bay deflection obtained in Operation 1, and was included.

(*b*) The transverse frame was first assumed to be pin-jointed and the forces in its members were found by applying the strain-energy method for a redundant frame, the loads obtained from (*a*) being used.

(*c*) The vertical and transverse horizontal displacements of the joints due to (*a*) were next calculated from the forces obtained in (*b*).

(*d*) The displacements found in (*c*) will affect the diagonal member forces found by Operation 2. The latter were next corrected to include the effect of the former, the consequent alteration in the longitudinal displacement of the structure being taken into account.

The processes (*a*), (*b*), (*c*) and (*d*) were then repeated until no appreciable change was obtained by any further application. The correction for the longitudinal displacement of the joints also necessitated the application of successive approximations, the results of which, when plotted, gave a curve which tended to stabilise. From this curve the final results were calculated. From (*d*) the final forces in the diagonal and transverse members were obtained.

OPERATION 4.

The longitudinal displacement of each joint was calculated from the results of Operation 3 and the final forces in the longitudinal members were then obtained from these longitudinal displacements.

The vertical deflection of all joints from the addition of the vertical deflections obtained in Operations 1 and 3 were next found.

OPERATION 5.

The bending moments of the joints were calculated from the relative end deflections of the longitudinal and transverse members. These moments were then balanced on Southwell's principle of relaxing each joint in turn.* The final bending moments were obtained by the application of the Hardy Cross method of successive approximations.† The bending moments due to the initial lack of straightness of the longitudinal members were included.

During the above application of successive approximations to this structure, conditions causing small effects were neglected on the first application. On each successive application more of these conditions were included. In the final application all conditions which affect the problem, within the limits of accuracy required, were taken into account.

Owing to the high initial tension put in the diagonal wires during the erection of the structure, the wires may be regarded as capable of withstanding compressive forces. In no case was the compression in any wire sufficient to overcome the initial tension.

The forces in the members calculated by this method of successive approximations are given in the first column of Table I. The bending moments in the longitudinal members calculated by this method are shown in the bending moment diagrams of Fig. 7.

In deriving the analytical solution the following assumptions were made:—

(1) No distortion of the rigid joint castings.
(2) No movement of the fixed end of the model.
(3) The friction of wires at their joints and at their points of intersection is small and may be neglected.
(4) Any eccentric loading due to faulty workmanship in the construction of the model is neglected.

The effect of assumption (4) had to be taken into account at the end of the solution in order to compare the calculated bending moments with the measured. This was due to the considerable bending moment caused by the initial lack of straightness in the members.

(4) BENDING MOMENTS FROM MEASUREMENT OF SKIN STRESS.

In order to obtain the vertical bending moments in the members of the structure, the longitudinal skin stresses were measured at various sections of the longitudinal and transverse members. At a particular section, the skin stresses were measured at the two opposite edges of the tube on a section perpendicular

* "Stress-Calculation in Frameworks by Method of Systematic Relaxation of Constraints," by Southwell. Proc. Roy. Soc., Vols. 151 and 153. Also, "The General Theory of Relaxation Methods applied to Linear Systems," by G. Temple. Proc. Roy. Soc., Vol. 169.

† "Analysis of Continuous Frames by Distributing Fixed-end Moments," by Hardy Cross. Proc. Amer. Soc. Civil Engineers, May, 1930, with discussion September, 1930, to April, 1932.

to its longitudinal axis. From the difference of the stress in these two opposite edges the bending moment can be calculated by the simple bending theory.

Let f_1 = stress at upper edge of longitudinal at a given section;
f_2 = stress at lower edge of longitudinal at same section;
f = max. bending stress of longitudinal at same section.
Then $f=(f_1-f_2)/2$ and $M=fI/y$ (from simple bending theory).

Each longitudinal and transverse member was divided up into 3 in. sections along its length. The skin stresses on opposite edges of these 3 in. lengths were then measured by an optical extensometer, of the Bauschinger-Marten type, whilst the model was loaded, and curves were plotted with the results obtained.

The alteration in tension in the wires during the loading of the model was also measured by means of an optical extensometer.

The optical extensometers used were designed to read extensions to an accuracy of two-millionth of an inch; stresses to the nearest $2\frac{3}{4}$ lb. per sq. in. could be measured with this instrument.

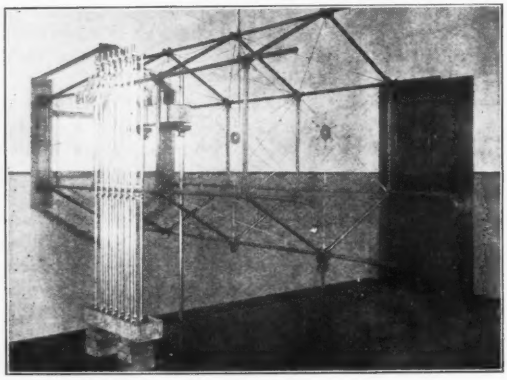


FIG. 4.

At each section under test, readings were taken for each 100 lb. of loading on the model, both during loading and unloading. Load extension curves were plotted for both edges of the section; the stresses were then calculated from the curves. The force in each member was calculated from the mean stress; these forces are entered in the second column of Table I. The bending moments in the longitudinal members obtained from these experiments are shown plotted in the bending moment diagrams of Fig. 7.

5. BENDING MOMENTS FROM MEASUREMENT OF SLOPES.

On the suggestion of Professor Pippard, a series of experiments was conducted with the purpose of obtaining the bending moments in the longitudinal members from their slopes. This provides a check on the bending moment diagrams obtained experimentally by measurement of skin stress. Work on the measurement of slopes of a girder, throughout its length, were already being carried out in the Mechanical Test Department of the Royal Aircraft Establishment at Farnborough. The author was shown this work by the officers in charge, who kindly allowed him to take details of the instruments used.

By measuring the change of slope at numerous sections of a longitudinal girder, caused by the loading of the model, it is possible to calculate the bending moments at these sections by making use of the simple bending theory. The length of each longitudinal member was marked off into 17 sections, $1\frac{1}{2}$ inches apart. The change of slope at each of these sections was measured during the loading and

unloading of the model. The change of slope thus obtained was then plotted on a base representing the longitudinal member and a smooth curve drawn through the points. By differentiating this curve, the bending moment diagram was obtained.

The instrument designed for the measurement of slope was made on the same principle of that used by the Royal Aircraft Establishment at Farnborough. It consisted of two long vertical levers; one firmly fixed to the longitudinal member and containing a graduated scale at its upper end; the other suspended freely from the longitudinal member, having a microscope at the upper end, the lower end being weighted and acting as a pendulum. The latter lever consequently remained truly vertical whilst the former changed its slope with that of the longitudinal member, thus displacing its scale. This displacement of the scale could be read by means of the microscope fixed to the vertical lever. Damping vanes, immersed in oil, were fixed to the levers, as shown in Fig. 4.

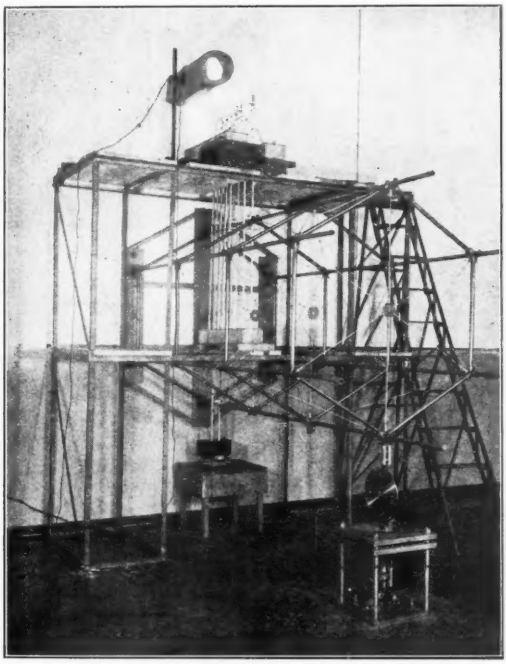


FIG. 5.

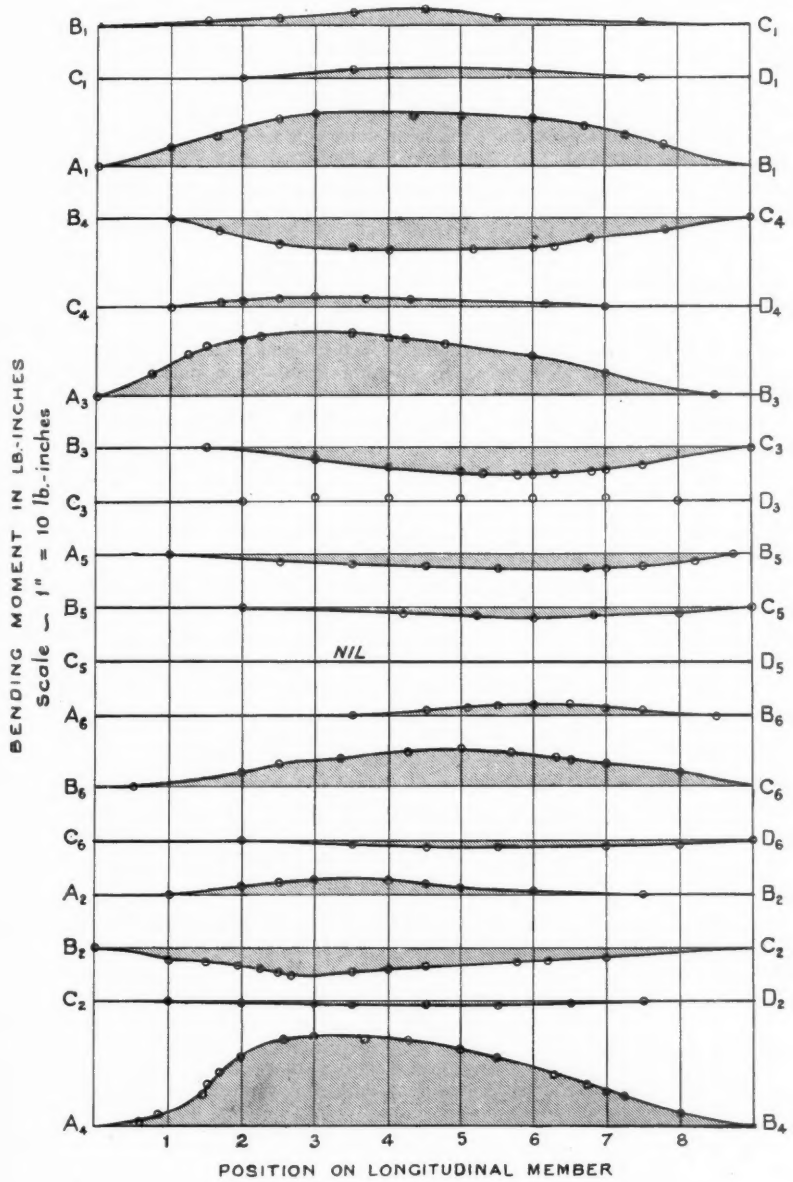
The instrument was designed so that it was perfectly balanced about the point of suspension.

On account of inaccessibility of the microscope of the instrument it was impossible to use this instrument on longitudinal 1. To overcome this difficulty, an optical type of instrument was designed. This was the same balanced pendulum instrument with the microscope and its scale removed. The levers were replaced by shorter tubes, the remaining parts of the instrument being as before. Small mirrors were fixed to the short tubes in place of the microscope and its scale. By means of a telescope sighted on these mirrors the reflection of an illuminated scale, placed about 15 feet away, could be seen. This instrument can be seen in position on longitudinal 1 in the photograph of Fig. 5.

TABLE I.

AXIAL FORCES IN MEMBERS (LBS.) DUE TO 400 LB. LOAD.

		Member.	RIGID JOINTS. Author's analytical solution.	RIGID JOINTS. Author's experimental measurements.	PINNED JOINTS. Southwell's solution (R. & M. 1528) Miss Chitty's application.	PINNED JOINTS. Pippard's experimental measurements (R. & M. 948).
Diagonal Members.	Bay AB.	${}_1T_2$	70.98	69.0	73.0	71.0
		${}_2T_1$	−31.65	−31.0	−32.7	−27.2
		${}_2T_3$	102.16	102.2	106.3	107.0
		${}_3T_2$	−99.45	−104.8	−104.1	−106.0
		${}_3T_4$	28.43	22.7	27.9	27.5
		${}_4T_3$	−69.60	−66.9	−70.4	−69.4
	Bay BC.	${}_1T_2$	60.84	60.5	63.9	61.2
		${}_2T_1$	−41.31	−39.7	−41.4	−38.2
		${}_2T_3$	103.25	107.2	107.5	104.0
		${}_3T_2$	−100.02	−100.8	−104.6	−106.4
		${}_3T_4$	34.96	30.7	34.8	39.1
		${}_4T_3$	−56.66	−54.8	−60.4	−62.2
	Bay CD.	${}_1T_2$	45.46	45.0	47.7	51.0
		${}_2T_1$	−41.18	−38.8	−42.6	−41.3
		${}_2T_3$	96.16	95.8	99.8	94.5
		${}_3T_2$	−92.50	−92.7	−95.5	−99.5
		${}_3T_4$	66.27	68.6	71.3	70.4
		${}_4T_3$	−67.97	−67.9	−72.4	−70.4
Longitudinal.	Bay AB.	A_1B_1	338.0	361.8	350.9	—
		A_2B_2	177.4	199.2	186.7	—
		A_3B_3	−152.2	−176.2	−157.1	—
		A_4B_4	−389.4	−388.0	−410.0	—
	Bay BC.	B_1C_1	196.0	210.0	202.4	—
		B_2C_2	108.2	120.0	111.9	—
		B_3C_3	−77.4	−86.5	−75.9	—
		B_4C_4	−259.5	−256.4	−274.3	—
	Bay CD.	C_1D_1	63.0	69.2	65.5	—
		C_2D_2	36.1	39.4	36.7	—
		C_3D_3	−21.6	−25.6	−21.0	—
		C_4D_4	−101.5	−100.3	−109.6	—
Transverse Members.	Frame.					
	D	1.2.	−38.9	−41.4	−39.7	—
		2.3.	53.1	53.9	52.0	—
		3.4.	160.3	162.9	162.3	—
	C	1.2.	−11.04	−11.8	−12.1	—
		2.3.	3.86	6.58	4.6	—
		3.4.	4.16	4.62	5.2	—
	B	1.2.	−18.86	−18.0	−20.0	—
		2.3.	−2.56	0.044	−1.9	—
		3.4.	20.79	17.25	21.9	—
Radial Wires.	D	0.1.	64.9	69.2	67.0	—
		0.2.	8.1	6.75	9.1	—
		0.3.	−114.6	−112.0	−115.9	—
		0.4.	186.4	185.8	192.1	—
	C	0.1.	7.99	8.1	8.0	—
		0.2.	−1.61	−0.75	−1.5	—
		0.3.	−10.31	−10.82	−12.2	—
		0.4.	16.19	19.22	18.8	—
	B	0.1.	−0.44	−0.175	0.01	—
		0.2.	−0.14	0	−0.29	—
		0.3.	1.41	−0.35	0.86	—
		0.4.	−2.09	0.048	−1.14	—



BENDING MOMENT

DUE TO INITIAL LACK OF STRAIGHTNESS OF TUBES

FIG. 6.

By means of this optical instrument changes of slope to an accuracy of 1/100,000th of a radian could be measured.

At each section under test, the slope was measured for each 100 lb. of load applied to the structure, both during loading and unloading; the results were then plotted, the final change of slope used being taken from the straight line graph thus obtained.

The bending moments on the longitudinal members obtained by this method are shown plotted in the bending moment diagrams of Fig. 7.

6. Bending Moment Due to Initial Lack of Straightness of Longitudinals.

It was observed by measurement that there was an initial lack of straightness in the tubes forming the longitudinal girders. This is unavoidable in the manufacture of the tubes and in the erection of the model. The effect of this lack of straightness, when combined with the longitudinal axial force in the member, causes bending moments of varying magnitude along its length.

The initial lack of straightness in the longitudinal members was measured by means of a straight-edge and engineer's feeler steel. The measurements were taken along the whole length of the member and were made to the nearest one-thousandth of an inch.

The offset measurements were then multiplied by the longitudinal force in the member, the result giving the bending moments due to this cause. The bending moment diagrams thus obtained are shown in Fig. 6. These diagrams were then added algebraically to the calculated bending moments. The resulting bending moments on all longitudinal members are shown plotted in Fig. 7.

7. Comparison of Bending Moment Diagrams.

The bending moment diagrams of all the longitudinal members are shown plotted in Fig. 7. On each longitudinal member is shown plotted, to the same scale, the bending moment diagrams obtained from the following three methods:—

(1) From experimental measurement of skin stress.
(2) From experimental measurement of slopes.
(3) From analytical solution.

The bending moment diagrams obtained from the analytical solution include the effect of the initial lack of straightness.

It will be noticed that the three sets of bending moment diagrams are in close agreement, especially those of the longitudinals bounding the vertical panels. Slight discrepancies occur near the wall end. At this end it will be noticed that even the two experimentally measured diagrams do not agree exactly. This is probably due to the " giving " of the wall. It was found by measurement that the wall joints were not only displaced longitudinally, but were also subjected to changes of slope. It is impossible to calculate these movements in a wall consisting of brick and concrete and which transmits the forces to the foundations of the building.

Other irregularities are due to joint friction and to a slight and unavoidable eccentricity in the application of the load. This eccentricity may vary with each application of the load.

It was found by measurement that the buckling effect of the compression members was extremely small and did not noticeably affect the bending moment diagrams.

8. Comparison of Forces in Members.

The axial forces in the members are entered in Table I. The first column gives the forces obtained from the analytical solution; the second column gives the forces obtained from the skin stress measurements. In the third column are given the forces obtained from Miss Chitty's application of Southwell's solution for the same structure, but fitted with pin-joints. Pippard's measured

results for this pin-jointed structure are given in the fourth column; in this case, the diagonal wire forces only are entered, the forces in the remaining members not being known.

From a comparison of the first and second columns it will be seen that the calculated forces are in close agreement with the measured, for the rigid-jointed structure. The largest discrepancies occur in the longitudinal members. This is probably due to the longitudinal movement of the wall, which was not taken into account in the analytical solution.

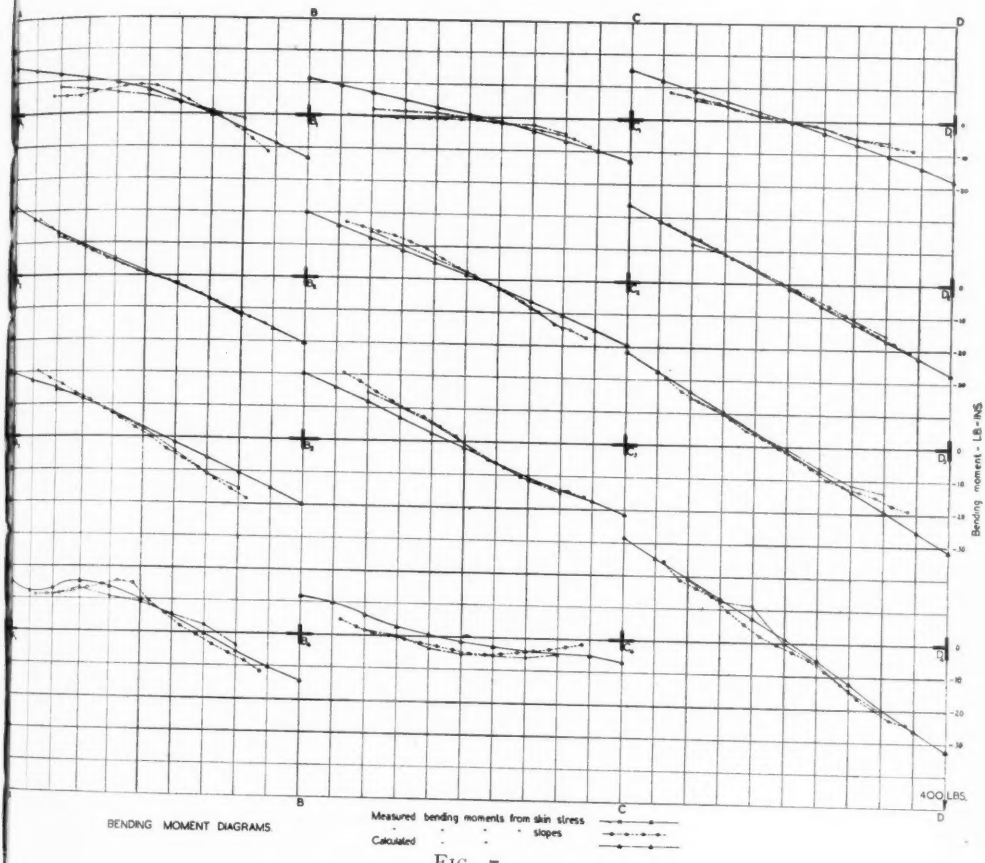
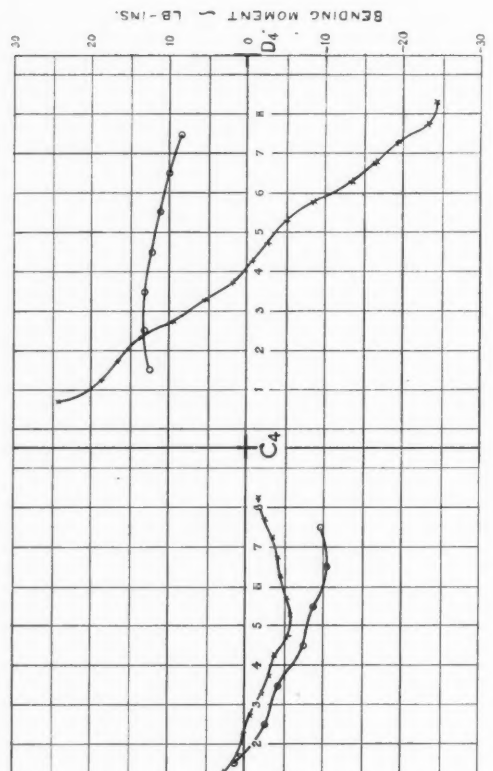


FIG. 7.

From the third and fourth column it will be seen that the forces in the pin-jointed structure were, on the average, about 3 per cent. larger than those of the rigid-jointed structure; this agreed with the calculated proportion.

It may be concluded from these results that the effect of the rigid joints is to reduce the axial forces in the members; the amount of reduction will depend on the relative stiffness of the structure to shear deflection and of the longitudinals to bending. In this type of model the amount of vertical shear taken by the longitudinals was relatively small, but in the case of an actual structure, this amount is much larger and may, in fact, be equal to one half of the total shear force on the structure.



EFFECT OF ECCENTRICITY OF LOAD ON BENDING MOMENTS.

Bending Moment with eccentricity
" " without "

Fig. 8.

9. The Effect of Rigid Joints on the Maximum Stress.

The maximum stress in the longitudinal members is increased, owing to the rigid joints, by the skin stress due to bending. The maximum stress in these members is the direct stress due to the axial force plus the bending stress. The values of these stresses are given in Table II and the percentage increase in stress, due to bending, is given in the last column. The maximum bending moment was obtained by extrapolation from the diagrams of Fig. 7.

Table II.

Longitudinal member.	Mean (or direct) stress. (lbs. per sq. in.)	Maximum bending moment. (lbs. in.)	Bending stress. (lbs./sq. in.)	Maximum stress. (lbs./sq. in.)	Percentage increase due to bending moment.
A_1B_1	4,632	20.0	1,267	5,899	27·4
B_1C_1	2,694	11.0	699	3,392	26.0
C_1D_1	886	11.0	699	1,585	79.0
A_2B_2	2,558	22.5	1,425	3,983	55·7
B_2C_2	1,540	24.6	1,560	3,100	101.2
C_2D_2	505	26.0	1,650	2,155	327.0
A_3B_3	2,274	28.5	1,803	4,077	79·3
B_3C_3	1,111	27.0	1,718	2,829	154·5
C_3D_3	326	26.5	1,680	2,006	515.0
A_4B_4	4,960	17.2	1,090	6,050	22.0
B_4C_4	1,357	8.0	508	1,865	37·5
C_4D_4	3,075	34.0	2,160	5,835	58.8

It will be seen from Table II that the greatest increase in stress due to the rigid joints was 515 per cent. and occurred in longitudinal C_3D_3, but this member was subjected to the least axial force. The highest stressed member was A_4B_4; this was subjected to a 22 per cent. increase of stress due to bending.

From these results it may be concluded that the effect of the rigid joints on the maximum stress is considerable.

10. The Effect of Eccentricity of Load.

In the loading of the model, great care was taken to insure that there was no eccentricity of the 400 lb. load. It was found that a slight amount of eccentricity caused a large change of bending moment on the adjacent members.

In Fig. 8 are shown two bending moment diagrams on longitudinal 4 which were obtained experimentally. One curve is the bending moment diagram due to the 400 lb. load, suspended from the model without any eccentricity; the other is the bending moment diagram due to the 400 lb. load being suspended with an eccentricity of 0.3 inches.

It will be noticed that the additional bending moment due to the eccentricity of the load tends to reduce as it travels along the girder. In this case it has vanished when the joint B is reached. This is explained by the fact that the eccentricity of the 400 lb. load causes a shear as well as a bending moment in the longitudinal. The direction of this shear is such that it causes a moment of the opposite sign to that of the initial bending moment produced. The two will thus tend to equalise each other during their transmission along the girder.

The author wishes to express his thanks to Professor Pippard for his valuable suggestions and advice, and to Professor C. H. Lander for his kindness in providing facilities for this work, the whole of which was carried out in his department at the City and Guilds College, South Kensington, S.W.7.

A NOTE ON THE DETERMINATION OF THE DRAG OF RETRACTABLE UNDERCARRIAGES IN FLIGHT.

By J. A. C. Williams, Grad.R.Ae.S.

Upon occasion it is required to find the drag of aircraft components which are normally retracted in level flight, such as flaps and undercarriages. The usual method of obtaining this drag from flight tests, is to measure speeds in level flight under known engine conditions with the component retracted and then with the component down. The difference of speed so obtained, together with the known test conditions then yields an answer. The disadvantage of this method is that, as the difference of speed is usually large, incidence changes and airscrew and engine assumptions cause discrepancies in the results. The difference of power between different engines of a type can be ± 5 per cent. A method is proposed which will enable most of the disadvantages of the older method to be overcome.

The method suggested does not rely upon any assumptions of airscrew efficiency and engine power, and consists of the measurement of a level speed and a rate of descent. The level speed is measured at a height "h" with component up, under known conditions of engine R.P.M. and throttle setting. The machine is then climbed to a height greater than "h"—say 1,000 ft. above—and a steady powered descent made with component down at the same indicated speed as that obtained for the level speed and using the same engine R.P.M. and throttle conditions. This descent is timed over a range of altitude from, say, 1,000 ft. above to 1,000 ft. below "h."

The value of the drag is then determined from the formula:—

$$\frac{\Delta \text{ drag}}{q} = \Delta C_D A = \left\{ \frac{4{\cdot}47\, W\,(R/D)}{\sigma V^3} + \frac{7{\cdot}92\,(W/b)^2\,(R/D)^2}{(\sigma V^3)^2} \right\}$$

where σ is relative density at height "h."

V is true speed in m.p.h. at height "h."

R/D is measured rate of descent at height "h" in ft./min.

W is weight of machine (lbs.).

b is wing span (ft.).

q is dynamic head.

This formula is seen to be free from any terms other than those known or measured.

If it is desired to eliminate slipstream effect, a similar method can be applied using two descents with the engine off and airscrew feathered, one descent with component up and the second with component down.

The method outlined above will occupy a negligible amount of time in excess of that required for the flight testing, using the old method and the accuracy of the results will be greater.

An example is given in order to show the probable values that might be experienced:—

An aircraft, undercarriage up, with a given set of engine conditions gave a level speed at 15,000 ft. of 190 m.p.h. true (151 m.p.h. corrected I.A.S.). A

powered descent at 151 m.p.h. corrected I.A.S., under the same engine conditions, gave a R/D (from test results) of 800 ft./min. at 15,000 ft./min.

W 18,000 lbs., b 75 ft., σ 15,000 ft. 0.629.

$$\therefore \Delta C_D A = \left\{ \frac{4.47 \times 18{,}000 \times 800}{0.629 \times 190^3} + \frac{7.92\ (18{,}000/75)^2\ 800^2}{(0.629 \times 190^3)^2} \right\}$$
$$= \{\ 14.9 + 0.02\ \} = 14.92 \text{ ft.}^2$$

or drag at 100 ft./sec. sea level

$$= 11.9 \times 14.92 = 177 \text{ lbs.}$$

This includes the drag of the nacelle undercarriage opening.

Appendix.

Derivation of Formula.

The author has made a departure from normal usage in that the drag coefficient is not separated from the area term and is thus expressed as $C_D A$ (ft.)^2. This follows the work in ref. 1. $C_D A$ is not dependent on wing area being merely

$$= \frac{\text{drag of object}}{q\ (= \frac{1}{2}\rho v^2)} \text{ and is } = \frac{\text{drag at 100 ft./sec. sea level}}{11.9}$$

It is felt that relating the drag coefficient of an undercarriage or fuselage to a wing area is not a very good procedure, conveying, as it does, no idea of the size or power required to overcome drag and necessitating alteration of the drag coefficient when the wing area is altered (as is done frequently in initial design), $C_D A$ is used in preference to drag at 100 ft./sec. at S.L. owing to the use of the performance methods of ref. 1, but the values are easily changed from one to the other.

Let

$$C_D A = \frac{\text{profile drag of machine at high speed}}{q}$$

$$\Delta C_D A = \frac{\text{drag of component (ft.}^2)}{q}$$

γ° = angle of descent.

σ, R/D, V and W as already defined.

Then

(1) with component up at height "h," for steady flight

$$\text{H.P. req.} = \underbrace{C_D A \sigma \left(\frac{V}{52.8}\right)^3}_{\text{(profile drag)}} + \underbrace{\frac{p\ (W/b)^2 \cos^2 \gamma}{3\ \sigma V}}_{\text{(induced drag)}}$$

p is constant and taken $\div$ 1.25

$\gamma = 0^\circ$ for a level speed.

(2) with component down at height "h"

$$\text{H.P. req.} = (C_D A + \Delta C_D A)\ \sigma \left(\frac{V}{52.8}\right)^3 + \frac{p\ (W/b)^2 \cos^2 \gamma}{3\ \sigma V}$$

Subtracting, at height "h"

$$\text{H.P. req.}_2 - \text{H.P. req.}_1 = \Delta C_D A \sigma \left(\frac{V}{52.8}\right)^3 - \frac{p\ (W/b)^2 \sin^2 \gamma}{3\ \sigma V}$$

As the engine and airscrew conditions at height "h" are identical in the two cases, the difference in H.P. req. is supplied from the rate of descent and

$$= \frac{WR/D}{33{,}000}$$

Substituting and remembering

$$\sin \gamma = \frac{R/D}{88\ V}$$

$$\Delta C_D A = \left\{ \frac{WR/D}{33{,}000} + \frac{p\,(W/b)^2\,(R/D/88\ V)^2}{3\,\sigma V} \right\} \frac{1}{\sigma} \left\{ \frac{52.8}{V} \right\}^3$$

simplifying with $\rho = 1.25$

$$\Delta C_D A = \left\{ \frac{4{\cdot}47\ W\ R/D}{\sigma V^3} + \frac{7{\cdot}92\,(W/b)^2\,(R/D)^2}{(\sigma V^3)^2} \right\}$$

The last term is, in general, very small and can be neglected.

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REVIEW.

FLIGHT WITHOUT POWER.

L. B. Barringer. Pitman Publishing Corporation, New York. $3.50. (17/6 net. Pitman and Sons.) 1940.

The author, Lewin B. Barringer, former editor of *Soaring* and Manager, the Soaring Society of America, is well qualified to write this book in collaboration with a number of specialists. He began gliding in 1930, is a holder of the coveted Silver C, holds the American record gliding distance of 212 miles and other gliding records, and is also a commercial pilot.

The first chapter is written by N. H. Randers-Pehrson, a member of the staff of the Division of Aeronautics of the Library of Congress. Here appear the names of those pioneers, Sir George Cayley, Lilienthal, Pilcher, Chanute, Herring, Montgomery, and the Wright brothers, followed by a host of modern gliding experts who have built so firmly on foundations so truly laid by the early pioneers. It is noteworthy that in 1911 Orville Wright glided for 9 minutes 45 seconds, a record which stood for ten years. The gliding record is now over 36 hours solo and over 50 hours in a two-seater, the distance flown 465 miles and altitude 22,434 feet; remarkable achievements which in themselves are a tribute to the value of gliding. It is significant in this connection that by the end of 1938 the total Silver C certificates won by Germany was 816, with Poland as its nearest competitor 159 and England third with 50.

Chapter II covers the aerodynamics of soaring flight. The explanations are clear and sufficient for the gliding enthusiast without going into the deeper niceties of boundary layer control and the like.

Types of gliders follow in Chapter III, from the primary to the all-metal, high performance sailplane, and the succeeding chapter deals with design, construction and maintenance, descriptively and generally. Launching methods form the subject of Chapter V and Soaring Meteorology that of Chapter VI. Modern gliding research has brought many new terms into meteorology and from gliding research meteorologists have probably learnt nearly as much as gliding pilots have learnt from meteorology. Instruments, training, soaring technique and soaring sites are covered in the remaining chapters.

" Flight without Power " is an excellent book for all those who are interested in or wish to be interested in gliding and soaring. The beginner and the expert equally will find something in it from which he can learn.

Gliding is primarily a sport, but it has one great possibility which cannot be overlooked. In the modern high performance sailplane the meteorologist has at hand one of the finest methods of obtaining information about the movements of the atmosphere he could possibly wish to have. A properly organised regular series of soaring observations from various selected meteorological stations would prove of great value.

ADDITIONS TO LIBRARY DURING 1940.

(Pamphlet Literature in Italics, with location reference following in brackets; books marked * or ** are not available for loan. A * at the head of a Section indicates that all books in this Section are for reference only.)

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*No. 1847. An Investigation of Ground Effect with a Model of a Mid-Wing Monoplane. By E. Ower, R. Warden and W. S. Brown. 4/-.

*No. 1849. (Revision of No. 1675). A Graphical Method of Calculating the Performance of an Airscrew. By C. N. H. Lock. 12/-.

*No. 1850. Reports and Memoranda published between 1st December, 1936, and 30th June, 1939. 1/3.

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No. 736. Tide-water and Weather-Exposure Tests on Metals Used in Aircraft. By W. Mutchler and W. G. Galvin.

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No. 738. Corrugated Metal Diaphragms for Aircraft Pressure-Measuring Instruments. By W. A. Wildhack and V. E. Goerke.

No. 739. A Recurrence Formula for Shear-Lag Problems. By Paul Kuhn.

No. 740. Stress Concentration around an Open Circular Hole in a Plate subjected to Bending Normal to the Plane of the Plate. By C. Dumont.

No. 741. Observations in Flight of the Region of Stalled Flow over the Blades of an Autogiro Rotor. By F. J. Bailey and F. B. Gustafson.

No. 742. Pressure-Distribution Measurements on a Rectangular Wing with a Partial-Span Split Flap in Curved Flight. By Frank G. Rokus.

No. 743. Local Instability of Columns with I-, Z-, Channel- and Rectangular-Tube Sections. By E. Z. Stowell and E. E. Lundquist.

No. 744. The Development of Electrical Strain Gauges. By A. V. de Forest and H. Leadermann.

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No. 745. Tests of a Gust-Alleviating Flap in the Gust Tunnel. By P. Donely and C. C. Shufflebarger.

No. 746. The Frequencies of Cantilever Wings in Beam and Torsional Vibrations. By C. P. Burgess.

No. 747. Propeller Rotation Noise due to Torque and Thrust. By Arthur F. Deeming.

No. 748. Principles, Practice and Progress of Noise Reduction in Airplanes. By Albert London.

No. 749. A New Method of Studying the Flow of the Water along the Bottom of a Model of a Flying-boat Hull. By Kenneth E. Ward.

No. 750. A Generalised Vortex Theory of the Screw Propeller and its Application. By Hans Reissner.

No. 751. Damping Formulas and Experimental Values of Damping in Flutter Models. By Robert P. Coleman.

No. 752. An Investigation of Sheet-Stiffener Panels subjected to Compression Loads with particular reference to Torsionally Weak Stiffeners. By Louis G. Dunn.

No. 753. Measurement of the Forces acting on Gliders in Towed Flight. By W. B. Klemperer.

No. 754. An Investigation of the Prevention of Ice on the Airplane Windshield. By Lewis A. Rodert.

No. 755. Wind-Tunnel Investigation of an N.A.C.A. 23030 Airfoil with various arrangements of Slotted Flaps. By I. G. Recant.

No. 756. The Effect of Piston-Head Shape, Cylinder-Head Shape and Exhaust Restriction, on the Performance of a Piston-Ported Two-Stroke Cylinder. By A. R. Rogowski, C. L. Bouchard and C. Fayette Taylor.

No. 757. A Study of Unsymmetrical-Loading Conditions. By Henry A. Pearson.

No. 758. Measurements and Analysis of the Motion of a Canard Airplane in Gusts. By P. Donely, H. B. Pierce and Philip W. Pepoon.

No. 760. A Full-Scale Investigation of the Effect of several Factors on the Shimmy of Castering Wheels. By Walter B. Howard.

b. **Reports**

No. 661. Tests in the Variable-Density Wind Tunnel of the N.A.C.A. 23012 Airfoil with Plain and Split Flaps. By I. H. Abbott and Harry Greenberg.

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No. 662. Design of N.A.C.A. Cowlings for Radial Air-Cooled Engines. By George W. Stickle.

No. 664. Wind-Tunnel Investigation of an N.A.C.A. 23012 Airfoil with various arrangements of Slotted Flaps. By C. J. Wenzinger and Thos. A. Harris.

No. 665. Calculation of the Aerodynamic Characteristics of Tapered Wings with Partial-Span Flaps. By H. A. Pearson and R. F. Anderson.

No. 667. Determination of the Profile Drag of an Airplane Wing in Flight at High Reynolds Numbers. By Joseph Bicknell.

No. 668. Wind-Tunnel Investigation of N.A.C.A. 23012, 23021 and 23030 Airfoils with various sizes of Split Flap. By C. J. Wenzinger and Thos. A. Harris.

No. 669. Airfoil Section Data obtained in the N.A.C.A. Variable-Density Tunnel as affected by Support Interference and other Corrections. By E. N. Jacobs and Ira H. Abbott.

No. 670. Tensile Elastic Properties of 18 : 8 Chromium-Nickel Steel as affected by Plastic Deformation. By D. J. McAdam, Jr., and R. W. Mebs.

No. 671. A Theoretical Study of the Moment on a Body in a Compressible Fluid. By Carl Kaplan.

No. 672. Free-Spinning Wind-Tunnel Tests of a Low-Wing Monoplane with Systematic Changes in Wings and Tails. IV. Effect of Center-of-Gravity Location. By Oscar Seidman and A. I. Neidhouse.

No. 673. Experimental Verification of the Theory of Oscillating Airfoils. By Abe Silverstein and Upshur T. Joyner.

No. 674. Cooling on the Front of an Air-Cooled Engine Cylinder in a Conventional Engine Cowling. By M. J. Brevoort and U. T. Joyner.

No. 675. Effects of Elevator Nose Shape, Gap, Balance and Tabs, on the Aerodynamic Characteristics of a Horizontal Tail Surface. By Harry P. Goett and J. P. Reeder.

No. 676. Surface Heat-Transfer Coefficients of Finned Cylinders. By H. E. Ellerbrook and Arnold Biermann.

No. 677. Wind-Tunnel Investigation of an N.A.C.A. 23012 Airfoil with various arrangements of Slotted Flaps. By C. J. Wenzinger and Thos. A. Harris.

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No. 678. Interference of Tail Surfaces and Wing and Fuselage, from Tests of 17 Combinations in the N.A.C.A. Variable-Density Tunnel. By Albert Sherman.

No. 679. Wind-Tunnel Investigation of an N.A.C.A. 23012 Airfoil with a Slotted Flap and Three Types of Auxiliary Flap. By C. J. Wenzinger and W. E. Gauvain.

No. 680. The Effect of Nacelle-Propeller Diameter Ratio on Body Interference and on Propeller and Cooling Characteristics. By J. G. McHugh and E. H. Derring.

No. 681. The Unsteady Lift of a Wing of Finite Aspect Ratio. By Robert T. Jones.

No. 682. Flame Speeds and Energy Considerations for Explosions in a Spherical Bomb. By E. F. Fiock, C. F. Marvin, F. R. Caldwell and C. H. Roeder.

* Twenty-Fifth Annual Report, 1939. (Administrative Report only, without Technical Reports.)

*c. **Technical Memoranda**

No. 901. Investigations and Experiments in the Guidonia Supersonic Wind Tunnel. By Antonio Ferri.

No. 902. Design of Centrifugal Impeller Blades. By A. Betz and I. Flügge-Lotz. (From Ingenieur-Archiv, Vol. 9, Dec., 1938.)

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No. 904. Stability of Rectangular Plates with Longitudinal or Transverse Stiffeners under Uniform Compression. By J. R. Barbre. Ingenieur-Archiv, Vol. 8, No. 2, 1937.)

No. 905. Temperature - Indicating Paints. By F. Penzig. (Z.V.D.I., Vol. 83, No. 3, Jan., 1939.)

No. 906. Forces and Moments on a Yawed Airfoil. By Sighard Hoerner. Luftfahrtforschung, April, 1939.)

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No. 908. Two-Stroke-Cycle Engines with Unsymmetrical Control Diagram. (Supercharged Engines.) (A.T.Z., August, 1938.) By J. Zeman.

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No. 933. The Strength of Shell and Tubular Spar Wings. By H. Ebner. (Luftfahrtforschung, April, 1937.)

No. 934. Application of the Methods of Gas Dynamics to Water Flows with Free Surface. Part I—Flows with no Energy Dissipation. By Ernst Preiswerk. (Institut der Aerodynamik, Technische Hochschule, Zürich.)

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*V. TRANSACTIONS AND PROCEEDINGS OF SOCIETIES

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2 Chartered Institution of Patent Agents. Transactions, Vol. LVII, 1938-39.

3 Institution of Automobile Engineers. Proceedings, Vol. XXXIII, Session 1938-39.

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Y. **BOX-FILES**

19 *Air Ministry D.T.D. Specifications.*
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24 *International Tin Research and Development Council.*
Fourth General Report, 1939.
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Z. **MISCELLANEOUS**

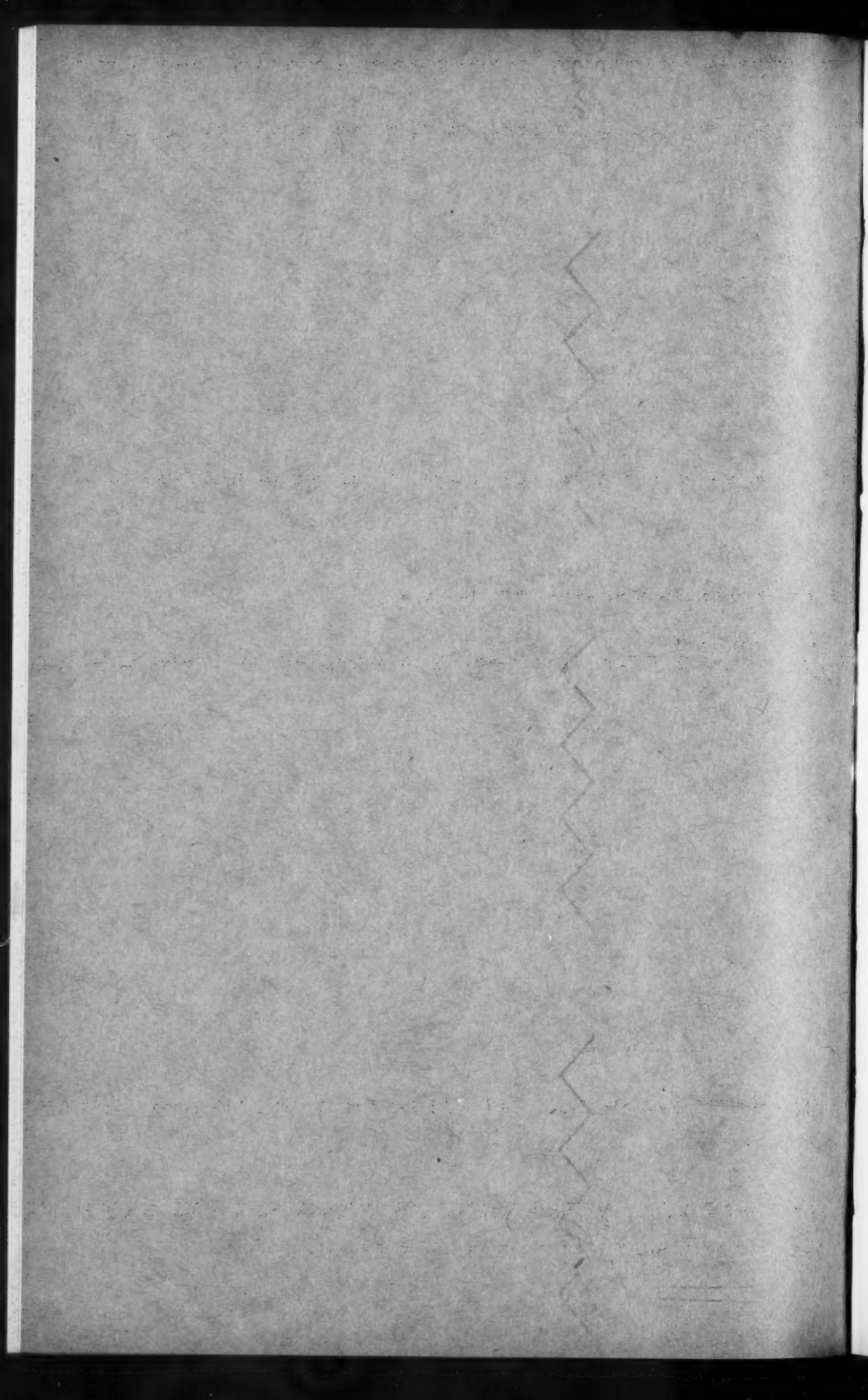
b. **Exhibition Catalogues**

38 Souvenir of International Aero Exhibition, Olympia, July 16-17, 1929.

g. **Dinner Menus**

**1 Collection of Autographed Luncheon and Dinner Menus (1914-1929).

NOTE.—It will be seen that the Section Numbers are not consecutive. The reason is that new books were being received whilst the Library was in process of re-classification. The missing numbers, therefore, represent books already in the Library.



ABSTRACTS FROM THE SCIENTIFIC AND TECHNICAL PRESS.

Issued by the

Directorates of Scientific Research and Technical Development, Air Ministry.

(Prepared by R.T.P.)

No. 79. JUNE, 1940.

New German Military Aircraft. (Les Ailes, No. 982, 23/5/40, p. 5.) (79/1 Germany.)

1. According to an Italian correspondent, flight tests have been carried out at Augsburg on a new Messerschmitt fighter known as Me 115. This aircraft is stated to employ a different wing section from the Me 109 and is fitted with special flaps ensuring manœuvrability in addition to high speed. The span has been reduced to less than 9.5 m., but the power plant (1,200 h.p. DB. engine), as well as many of the structural elements of the Me 109, have been retained. According to the French author this shows that the Germans are still clinging to their original tactics of using the fighter mainly as a means of intercepting bomber and reconnaissance machines rather than attack combat planes.

2. The Heinkel He 113 fighter which has been used in Norway appears to be another attempt of improving the Me 109. It has a smaller wing area than the He 112 and is armed with a cannon firing through the propeller axis and two heavy synchronised machine guns firing through the propeller disc. The following dimensions are given, but no performance data are available.

Span, 9.4 m.
Length, 8.18 m.
Height, 2.5 m.
Wing area, 14.5 m.

3. It is stated that series production of the DB. 603 engine (rated at 1,500-1,700 h.p.) is now well in hand and that the DO. 215 bombers will be fitted with these engines. The DB. 605 engine (2,000 h.p.) and a 1,500 h.p. twin row radial are still in the experimental stage.

Germany's Oil Consumption and Supplies. (Engineer, Vol. 169, No. 4,405, 14/6/40, pp. 537-538.) (79/2 Germany.)

It is commonly believed that a shortage or exhaustion of oil supplies will prove one of the decisive elements in the defeat of Germany. Unfortunately, any attempt to answer this question in its totality can only be founded on calculation, which, for certain of their vital data, must involve a considerable amount of guess work. It is, nevertheless, possible to arrive at a rough idea of Germany's present consumption of petrol by the air force alone by analysing the tank

capacity of the various types and making reasonable assumptions of the number of hours flown by each single machine. Working on these lines, the author concludes that the average fuel consumption for all classes of aircraft is of the order of two tons a day under conditions of intensive warfare. Assuming that 2,000 aircraft are engaged from day to day on active operations, the active battle units account for 4,000 tons of petrol per day, or 4,500 tons taking into account training machines and vehicles servicing the aircraft.

Turning next to tanks and assuming an average h.p. of 500 for 10 hours, we obtain a fuel consumption of one ton per tank per day. Taking 4,500 tanks in action per day, the daily fuel consumption is of the same order as that of the air force.

These estimates, it will be seen, can be substantiated to some extent. When, however, we consider the fuel consumption of mechanised army vehicles, naval and transport vessels and agriculture we are frankly guessing. The author's guess is 4,500 tons of oil or petrol fuel per day, thus giving a grand total of 5 million tons per year under conditions of intensive warfare. Neglecting all considerations of fuel stored or captured, these 5 million tons will have to be made up by

(1) Synthesis or other processes;
(2) Oil wells in Germany or Poland;
(3) Imports from Russia or Roumania.

Items (1) and (3) are uncertain. Item (2) is estimated at 1½ million tons.

Ground Attack Aeroplanes v. Armoured Divisions. (C. Rougeron, La Science et la Vie, No. 276, June, 1940, pp. 551-564.) (79/3 France.)

Before the recent mass utilisation of armoured divisions in France, the possibilities of such a method of attack had already been demonstrated in Spain, Poland and Finland. The tank is essentially a weapon of surprise and it is difficult to distribute the necessary anti-tank artillery so as to deal with every kind of emergency. Aircraft, however, can arrive quickly at the danger spot, although it may have originally been stationed at some distance. By diving on to the target at high speed, the impact velocity of the bullet is appreciably increased and the author is of the opinion that under these conditions a 12.7 or 20 mm. bullet should pierce armour plating of 25 or 40 mm. respectively. The 37 mm. aircraft cannon should perforate 60 mm. of armour, and although some German authorities talk about tanks fitted with 100 mm. armour, it is very unlikely that the thickness of the top plating is more than half this amount. The author gives some particulars of existing tanks (one American 8-ton, two Italian of 5.6 and 3.3 tons respectively) which have a top armour of only 5 to 6 mm. with side armour ranging from 8 to 16 mm. Such vehicles should prove very vulnerable to attack attack. Of course, the aircraft in its turn will be subjected to A.A. fire and enemy fighter attack. Unless the ground gun is in such a position that the aircraft, whilst carrying out the attack on the tank, is diving towards the gun, the chances of scoring a hit with ground artillery are very small.

Protective action by enemy fighters co-operating with the tanks is a more serious obstacle and it will probably be necessary to provide the ground attack machines with a fighter escort in its turn. In spite of these complications, however, the author is firmly of the opinion that surprise attacks by tanks and armoured divisions can only be dealt with effectively by ground attack aircraft.

Shell v. Armour. (P. Chaville, La Science et la Vie, No. 276, June, 1940, pp. 505-573.) (79/4 France.)

Some particulars of the Hotchkiss 13.2 mm. armour piercing bullet are given. This bullet consists of a pointed core of very hard steel, tipped with lead (the

whole enclosed in a sheathing of brass) and will perforate 45 mm. of steel (52 kg./mm.^{2} tensile) when impacting normally at 800 m./sec. At 400 m./sec., only 17 mm. of steel are pierced whilst an impact velocity of 200 m./sec. will perforate 6 mm. It must be emphasised that these figures only apply to normal impact on a homogeneous plate. If the bullet strikes at an angle, its effect is very much reduced. The same applies if the armour plate is not homogeneous, but consists of two outer plates and a filler. Such composite armour is always thicker than a homogeneous plate, but the great advantage consists in a considerable reduction in weight. Interesting photographs show the effect of firing the Hotchkiss bullet at 800 m./sec. into a pile of soft steel plates and into sand. In the latter case the bullet generally turns through a right angle before coming to rest, the brass sheath being completely stripped off. Similar phenomena arise if the bullet is fired into a block of lead. Although impacting normally one side of the block, the bullet actually leaves one of the lateral sides of the block after describing a parabolic path. Increasing the impact velocity under these conditions does not increase the actual depth of penetration, but only increases the lateral motion. Various explanations of this phenomenon have been advanced from time to time. According to the author, the principle of the conservation of momentum directly leads to this result, provided the medium into which the bullet is fired is sufficiently soft and sufficiently extended.

New Electrical Methods for Spotting Aircraft. (P. Hernardinquer, La Science et la Vie, No. 276, June, 1940, pp. 603-611.) (79/5 France.)

The usual acoustic spotter depends on the sensitivity of the ear of the observer. The ear drum, being essentially a stretched membrane, responds mainly to pressure differences, and is not very accurate in determining the direction from which the sound proceeds. A microphone of the " ribbon " type, on the other hand, follows molecular displacements in the direction of propagation of the sound and thus possesses marked " directional " sensitivity. The author describes the " Olson " microphone (U.S.A.) working on this principle and gives some particulars of the electric circuit employed, including the optical recording by means of a cathode ray oscillograph. By substituting this electrical recorder for the human ear not only is the sensitivity improved, but it is relatively simple to tune the system to become specially sensitive to certain aircraft sounds.

Acoustical spotting, even if improved in the above manner, is still subjected to considerable error by atmospheric conditions and, due to the relatively low value of the speed of sound, a further correction for the position of the aircraft is required. As a consequence many attempts have been made to use other means which are less subject to atmospheric disturbances. The use of short wireless waves which would be reflected by the aircraft obviously suggests itself. The broad outlines of such schemes are discussed, and although extravagant claims have appeared in the press from time to time, a really practical scheme is not yet available.

Anti-Aircraft Gunnery Training with the Help of the Cinematograph. (V. Rubor, La Science et la Vie, No. 276, June, 1940, p. 635.) (79/6 France.)

The aircraft target appears as a moving picture on a screen placed in front of a steel plate. When a bullet strikes the plate, the film is stopped and the perforation rendered visible by an electric light. A suitable delay action is incorporated in the mechanism so as to allow for the time of travel of the bullet, so that the relative position of the hole and image of aircraft corresponds to practical conditions.

After a few seconds, the hole in the screen is stopped up, the lights behind the screen go out and projection recommences.

The Unsteady Lift of a Wing of Finite Aspect Ratio. (R. T. Jones, N.A.C.A. Report No. 681, 1940.) (79/7 U.S.A.)

The two-dimensional potential theory of aerofoils in non-uniform motion was given by Wagner (Z.A.M.M., Vol. 5, No. 1, Feb., 1925, pp. 17-35) and has been extended to problems involving the motion of hinged or flexible aerofoils by Theodorsen (N.A.C.A. Report No. 496) and Küssner (L.F.F., Vol. 13, No. 12, 20/12/36, pp. 410-24).

In the case of steady motion, a correction is known to be necessary before the results of the two-dimensional theory can be applied to wings of finite aspect ratio. A theory for the unsteady lift of finite wings was developed in N.A.C.A. Tech. Note No. 682. This theory has since been somewhat improved mathematically by making use of operational methods in the solution of the integral equations. (See N.A.C.A. Tech. Note No. 667.) The present report combines this previous work and extends the theory to show the effects of gusts.

Unsteady lift functions for wings of finite aspect ratio have been calculated by correcting the aerodynamic inertia and the angle of attack of the infinite wing. The calculations are based on the operational method.

The starting lift of the finite wing is found to be only slightly less than that of the infinite wing, whereas the final lift may be considerably less. The theory indicates that the initial distribution of lift is similar to the final distribution.

Curves showing the variation of lift after a sudden unit change in angle of attack, during penetration of a sharp-edge gust, and during a continuous oscillation are given. Operational equivalents of these functions have been devised to facilitate the calculation of lift under various conditions of motion. As an application of these formulas, the vertical acceleration of a loaded wing caused by penetrating a gust has been calculated.

A Simplified Method of Determining Wing Profile Drag in Flight. (A. Silverstein, S. Katzoff, J. Aeron. Sci., Vol. 7, No. 7, May, 1940, pp. 295-301.) (79/10 U.S.A.)

The determination of wing profile drag by means of total pressure and static pressure measurements in the wing wake provides a technique applicable in flight. The use of the method is difficult, however, outside of a research laboratory without considerable simplification of instruments and calculations and extensive use by aircraft designers to study effects of wing surface roughness, protuberances, etc., is restricted.

In this paper the design of an instrument to simplify the pressure measurements is presented. It consists of a total head rake that can be attached to the wing trailing edge to measure the average total pressure in the wing wake. Charts are given to convert the average total pressures into drag coefficients. The calculations on which the instrument design and charts are based are given, together with instructions for practical application.

The Measurement of Dynamic Pressure in Flight. (H. Muttray, L.F.F., Vol. 17, No. 3, 20/3/40, pp. 65-69.) (79/8 Germany.)

The dynamic pressure is the difference between total and static pressures. Measurement of the total pressure in flight presents no difficulties. The static pressure is, however, very sensitive to local disturbances such as are naturally generated by the aircraft itself, and a really satisfactory measurement can only be obtained by towing a suitable recording instrument at a considerable distance from the aircraft. For general purposes the static pressure tube is attached to the aircraft and " calibrated " against the towed recorder. As this calibration must hold over a variety of flight conditions, it is obviously desirable to choose a position on the aircraft where the static pressure is disturbed as little as possible. In the case of biplanes, theory indicates that a good approximation to the

true static pressure should exist at some point between the two wings and a suitable position for the static pressure tube can be found relatively easily. In the more general case of the monoplane, Kiel (L.F.F., Vol. 15, No. 12, p. 583; A.M. Translation No. 868) has shown that the true static pressure can be obtained by providing an interconnection between the top and bottom wing surfaces and tapping off at a suitable point. The author shows that a simpler solution of the problem is provided by placing the static pressure tube at a small distance above the rudder unit. Elementary considerations based on the relationship between downwash and pressure show that the disturbance in the pressure field must be very small in that region and this was confirmed by the author's wind tunnel experiments. Any errors due to the flow being oblique at that point can best be avoided by mounting the pressure tube so that it can set itself automatically into the relative wind.

New Developments in the Theory of Aerofoils of Infinite Span. (R. von Mises, J. Aeron. Sci., Vol. 7, No. 7, May, 1940, pp. 290-4.) (79/9 U.S.A.)

This paper gives some supplementary developments and revisions of the two-dimensional aerofoil theory. (1) The chief results are reviewed and the concept of " second axis " of a profile is revised. (2) In discussing stability questions the theory of Hamilton's centre is referred to. (3) The method of successive approximations is outlined in its relation to the so-called thin wing theory. (4) The addition of two independent lift force systems is explained. (5) The general theorem is proved that in any case of several aerofoils with mutual interference the lift force follows the same laws in its dependency on the angle of attack as in the case of a single wing.

Aircraft Design in 1939. (Luftwissen, Vol. 7, No. 1, Jan., 1940, pp. 1-2.) (79/11 Germany.)

The year 1939 is memorable for bringing to Germany the absolute speed record for land machines. A speed increase of nearly 100 m.p.h. over the previous best is most remarkable considering that aircraft had already undergone a considerable development during recent years and a slowing up of the rate of progress was anticipated in many quarters. In the same year Germany obtained the speed record with a two-ton useful load over 1,000 and 2,000 km. In both cases the increased performance was mainly due to further improvements in aircraft design, although for the absolute speed record engine power naturally played a big part. Here the intensive development of liquid-cooled engines, taken up in Germany at a time when the air-cooled design clearly held the field, has justified itself. Experimental Atlantic flights have been carried out by Germany since 1936 and the Lufthansa would have been in a position to undertake a regular service already in 1938, if political difficulties had not arisen. The phenomenal progress achieved in Germany in recent years is largely due to the proper organisation of research and development and to the spirit of co-operation fostered in all branches of the industry. Practical experience was pooled and methods of overcoming difficulties were rendered available to all concerned in the shortest possible time.

Dornier Aircraft Development During the Last Twenty-five Years. (M. Kohler, Luftwissen, Vol. 7, No. 1, Jan., 1940, pp. 10-12.) (79/12 Germany.)

The earliest Dornier designs date back to 1915 (all-metal flying boats) and the single-seat fighter Do D1, built in 1918, was the first to utilise the now commonplace shell structure both for wings and fuselage. After 1918 considerable success was achieved with the civil flying boats of the Wal type (high wing monoplanes with engines in tandem and stub floats). The size of these boats gradually increased to 10 tons and a regular postal service to South America

was instituted in 1934. Improved versions of this design soon followed (Do 14, 18, 22, 24, and 26).

Outstanding land machines are the Do 11, 17, 19, 23 and 215, which form part of the equipment of the German Air Force.

Any review of Dornier development would be incomplete without reference to the Do X, a 60-ton boat with a wing area of 468 m.². This machine carried out a number of long distance flights in 1931 and 1932 and, although clearly before its time, valuable experience was gained.

It appears that the unit constructional weight of such large boats is distinctly favourable and that the improved stability of the hull when resting on the surface is a great advantage. On account of the lack of suitable power units at the time, the Do X had to be provided with 12 engines of 500 h.p. each, which is clearly not a practical proposition. With the recent advent of engines developing as much as 2,000 h.p. in one unit, boats of the size of the Do X will come into their own.

Discussion on the German Official Regulations Governing the Electric Equipment of Aircraft (Section 5/1 of General Regulations for the Construction of Aircraft—Parts I and II). (E. A. Reussner, Luftwissen, Vol. 7, No. 1, Jan., 1940, pp. 13-14.) (79/13 Germany.)

Section 1 of the general regulations for the construction of aircraft (known as B.V.F. regulations) was first issued in Jan., 1935 (latest edition Dec., 1936).

Section 3, covering the power plant, followed in April, 1938, and Section 5/1, covering electrical equipment (Parts I and II), was issued in Nov., 1939.

Preliminary regulations had, of course, been in use for a long time. Such regulations were, however, intended only as rough guides and lacked legal authority. The new official regulations are the outcome of the experience gained and special care was taken to make them sufficiently elastic to encourage future development. Requirements of a general nature to be satisfied by any type of equipment are thus kept distinct from those covering a given installation, whilst a final section deals with individual apparatus. " Electrical Equipment, Parts I and II," reviewed in the present article cover regulations of a general nature only.

Part I explains how the electrical circuits are conveniently sub-divided into a " principal " network together with " subsidiary " and " auxiliary " circuits. The " principal " circuit is fed by the major source of electrical supply directly whilst the " subsidiary " circuits are fed from the " principal " circuit with or without the help of transformers. " Auxiliary " circuits finally have their own source of current supply.

Part II deals with such general problems as supply voltage, and effect of position, temperature, pressure and corrosive influences on the lay-out of the circuits, special attention being given to the possible effects of moisture and the needs for accessibility and ventilation. Electrical insulation and protective devices, such as fuses and circuit breakers, are considered next, whilst a whole section deals with the problems of screening both for wireless as well as magnetic instruments.

A Study of Unsymmetrical Loading Conditions. (H. A. Pearson, N.A.C.A. Tech. Note No. 757, April, 1940.) (79/14 U.S.A.)

The force variation along the wing span under combined normal and angular accelerations is considered. Non-dimensional curves of section load, shear, and moment are given for :—

(1) The air load that produces a normal acceleration.
(2) The accompanying wing weight and normal inertia loads.
(3) Aileron and gust air loads that produce angular acceleration.
(4) The angular inertia load of the wing.

The required aerodynamic load distributions have been obtained by use of wing theory and the wing inertia distributions are based on an analysis of wing weight data.

Several examples are included to illustrate the effect of wing taper and aileron span on the total shears and moments at any section along the span.

U.S.A. Air Transport, 1939. (Inter. Avia., No. 709, 7/5/40, pp. 1-4.) (79/15 U.S.A.)

On January 1st, 1939, the United States possessed 14,300 aircraft, of which 30 per cent. represented military equipment, 30 per cent. pleasure and touring, 30 per cent. non-scheduled commercial, 8 per cent. business flying, and 2 per cent. scheduled air carriers (app. 300 machines). Over two million passengers were carried and nearly 100 million aircraft miles were flown. During the year nine passenger and three crew fatalities occurred, corresponding to one for every 82 million passenger miles and one for every 27 million crew miles respectively. The petrol and oil consumption during 1939 totalled 54 million gallons and one million gallons approximately.

General Relationships Between the Various Systems of Reference Axes Utilised in Flight Mechanics. (H. J. Rautenberg, L.F.F., Vol. 17, No. 4, 20/4/40, pp. 106-122.) (79/16 Germany.)

In flight mechanics three systems of axes are currently employed, these systems being fixed to the aircraft, ground, or relative wind respectively. The author shows that the most suitable coupling between the wind and aircraft axes is obtained if the y axis is made the principal axis of rotation, about which the incidence α is measured. This coupling is denoted as the "E" coupling and enables the utilisation of coefficients obtained in the wind tunnel in the flight mechanic equations. When transferring from aircraft or wind axes to ground axes, the simplest case arises if the z axis of the basic ground system and the x axis of either the aircraft or wind systems are made the principal axes of rotation respectively.

Vought-Sikorsky Helicopter VS-300. (Inter. Avia., No. 712, 29/5/40, pp. 17-18.) (79/17 U.S.A.)

The U.S. helicopter has no fixed surfaces. Control is obtained exclusively by means of rotors: A single main lifting rotor and three auxiliary rotors. The main rotor furnishes most of the lift and forms, by changes of the pitch of its blades, the basis of the control for up and down motion. The auxiliary rotors are situated beyond the disc of rotation of the main rotor on an outrigger. Two of the auxiliary rotors, located on vertical shafts on both sides of the outrigger, furnish means for longitudinal and lateral control. The variation of the pitches of both these rotors in the same direction produces longitudinal control, while the variation in opposite direction gives lateral control. The third rotor is situated on a horizontal axle placed transverse to the normal motion of the aircraft and furnishes a force that compensates the torque of the main lifting rotor. A mechanism varying the pitch of the rear rotor is connected with foot pedals and furnishes means for directional control of the aircraft. All controls are completely independent of the motion of the aircraft and of the power supplied by the engine. No structural details of the helicopter are available. Power is supplied by a Lycoming four-cylinder engine of 75 h.p. Data of the flight model: Diameter and speed of the main rotor, 28 ft. and 255 r.p.m. respectively; of the auxiliary rotors, 6 ft. 8 in. and 1,700 r.p.m. respectively; gross weight, 1,150 lb.; power loading, 15.3 lb.; average main rotor blade loading and disc loading, 51 lb./sq. ft. and 1.86 lb./sq. ft. (the latter figures are taken on the assumption that the whole load is carried by the main rotor).

Stresses in Single Spar Wing Constructions with Incompletely Built-up Ribs. (F. Reinitzhuber, L.F.F., Vol. 16, No. 7, 20/7/39, pp. 349-54. Air Ministry Translation T.M. 937.) (79/18 Germany.)

It is shown that the force distribution resulting from incomplete ribs in single spar wing structures may be determined with the aid of the shear field method by a statically indeterminate computation. A numerical computation is given of the force distribution of a wing structure whose two neighbouring incomplete ribs with web mission in half the section are torsionally loaded. In spite of the incomplete ribs, there is obtained a distribution of the applied forces over the entire wing cross section which depends considerably on the stiffness of the ribs, particularly of the flanges in the rear part of the tubes and of the manner of application of the forces on the rib. Through the use of simplifying assumptions, it is possible to reduce the number of static redundancies and thus the computation work without introducing much error in the results. If two equal and opposite moments are applied at the incomplete ribs, a onefold statically indeterminate computation is already sufficient for obtaining a useful approximate value of the moment contribution of the rear tubes.

The Shock Absorbing System of the Aeroplane Landing Gear. (P. Callerio, L'Aerotecnica, Vol. 19, No. 6, June, 1939, pp. 625-640. Air Ministry Translation T.M. 938.) (79/19 Italy.)

After a general discussion of the shock absorbing system under landing, take-off and taxying conditions, a general formula is derived by the author for the minimum stroke required to satisfy certain conditions. The operation of some typical shock absorbing systems is examined and it is pointed out that dynamic landing gear tests must take into account the effect of wing lift at the instant of contact with the ground. The presence of high lift devices especially may produce profound effect.

Reversible Pitch Propellers as Applied to Water Handling of Multi-Engined Flying Boats. (C. W. Chillson, J. Aeron. Sci., Vol. 7, No. 7, May, 1940, pp. 269-275.) (79/20 U.S.A.)

Brief mention is made of several reversible pitch propeller applications. Some of the problems encountered in the water handling of multi-engine flying boats are discussed. The use of reversible propellers is proposed as an aid to manœuvring, and tests are cited in which it was found possible to turn a four-engine flying boat in as small a radius as desired and to stop or to back against the wind. Adaptation of a conventional electrically controllable propeller for reverse pitch operation is illustrated schematically and described briefly. While engine cooling imposes limitations to protracted high power operation in reverse pitch, experience to date indicates that these limitations need not be exceeded in normal operation. Engine overspeeding while the blades are going through zero angle is prevented by engine and propeller inertia at moderate throttle settings and with available rates of pitch change. Limitations imposed by propeller blade and retention stresses and the effect of forward tilt thereon are discussed. No ill effects of negative thrust are to be expected on either engines or engine mounts.

Aluminium Aircraft Fuel Tanks. (E. H. Dix and R. B. Mears, J.S.A.E., Vol. 46, No. 5, May, 1940, pp. 215-20.) (79/21 U.S.A.)

Because of advantages of light weight, ease of fabrication, and high resistance to corrosion, aluminium aircraft fuel tanks have been used widely for two decades. Although it was established many years ago that dry gasoline does not corrode aluminium, pitting of the aluminium shell has occurred sometimes in the presence of badly contaminated water.

This corrosion can be prevented by designing tanks to permit free drainage of water to the sump; selecting metals to avoid electrolytic action; handling fuel so that it will not pick up water, iron rust, or other heavy metal corrosion products prior to the time that it is introduced into the aircraft fuel tank; applying suitable coatings to the aircraft interior; the use of Alclad sheet; employing corrosion inhibitors either in capsules inserted in the tank or as an addition to the fuel; and by periodic cleaning of the tank interiors or flushing them with inhibited solutions.

Some Economic Aspects of Transport Aeroplane Performance (Parts II and III). (W. C. Mentzer, H. E. Nourse, J. Aeron. Sci., Vol. 7, No. 7, May, 1940, pp. 302-8.) (79/22 U.S.A.)

Variation of aeroplane utilisation has a profound effect on significant operating cost. Aeroplane utilisation in terms of flying time is fundamentally dependent on trip length, with a secondary dependence on such factors as seasonal schedule changes, block speed, etc. (as block speed increases, utilisation decreases).

Material increases in aeroplane first cost can be justified if they result in a sufficiently great improvement of aerodynamic efficiency. The study indicates how rapidly significant operating cost increases on a modern conventional aeroplane as block speed increases when that increase in block speed is obtained only by the addition of power. This is true even if the gross weight is increased enough to offset the additional structure and engine weight. It is also shown that significant cost increases rapidly as trip length increases.

Propellers for Submerged Engines. (G. W. Brady, J.S.A.E., Vol. 46, No. 5, May, 1940, pp. 191-197.) (79/23 U.S.A.)

In the case of submerged engine installations, the nacelles housing the propeller drive are very small and even if a spinner is fitted, a considerable portion of the propeller blade shank must necessarily project into the slipstream. In the case of variable pitch propellers, the blade shank must be circular inside the hub, and if the blades are made of metal, the change in section as the working portion of the blade is approached must be very gradual if blade failure is to be avoided. The h.p. absorbed in overcoming the drag of these shanks is very considerable at high translational speed, and may amount to nearly 180 h.p. in the case of a 1,200 h.p. propeller moving at 400 m.p.h. By applying cuffs of suitable shape to these shanks, this drag can be halved. The anchoring of such cuffs to Al alloy blades presents considerable difficulties and this gives increased interest to alternative materials for propeller blades (steel or treated woods). In the case of treated wood, abrupt changes of blade section are possible and the cylindrical shank can be correspondingly shortened.

Apart from drag difficulties, the submerged installations will require considerable care in the design of the transmission gear so as to provide vibration isolation for the propeller.

Resonance Vibrations in the Induction and Exhaust Systems of In-Line Engines. (O. Lutz, L.F.F., Vol. 17, No. 4, pp. 123-128.) (79/24 Germany.)

This article forms Part III of a series, of which the first two dealt with resonance phenomena in pipe systems brought about by periodic changes in gas velocity. The present article deals with the effect of resonance vibrations on volumetric efficiency of piston engines. The author first considers the relatively simple case of flow through a variable throttle placed at the end of a pipe discharging into free atmosphere and then extends the case to the flow into a tank of finite capacity. Applying the results to the case of a single cylinder four-stroke engine, it is concluded that the increase in volumetric efficiency becomes most

marked in the immediate neighbourhood of the first resonance region. The extension to multi-cylinder in-line engines is broadly indicated and the application to a practical example will form the subject of a subsequent article.

Piston Ring Coatings and Their Effect on Ring and Bore Wear. (M. M. Roensch, J.S.A.E., Vol. 46, No. 5, May, 1940, pp. 221-8.) (79/25 U.S.A.)

Piston ring scuffing occurs most frequently during the break-in period and has been, for some time, a problem to both the automobile and ring producers. Ring coatings have been under development for several years and their general adoption by nearly all automobile companies indicates both the need for them and their effectiveness. The coatings fall into two general classes, chemical and metallic. The chemical are: Ferrox, an iron oxide; Granoseal, an iron-manganese phosphate; Graphitox and Grafotox, a zinc-iron phosphate with colloidal graphite; and Surfide, ferrous sulphide. The metallic coating is of electrolytically deposited tin.

Careful tests under accelerated wear or scuffing conditions on newly finished surfaces showed that untreated rings produced twice the wear that occurred on the coated rings when only the compression rings were coated.

The Synthesis of Lubricating Oils by Condensation Reactions. Part II. The Engine Testing of Synthetic Lubricants. (W. R. Wiggins, T. G. Hunter and A. W. Nash, J. Inst. Petrol, Vol. 26, No. 199, May, 1940, pp. 225-34.) (79/26 Great Britain.)

The engine service characteristics of two synthetic lubricating oils were evaluated by engine tests. The oils were:—

1. An oil made by condensation of chlorinated paraffin wax with benzene using an aluminium catalyst.
2. An oil made by condensation of chlorinated paraffin wax with benzene using an aluminium chloride catalyst.

The service characteristics evaluated were engine wear, oil consumption, carbon deposits and condition of oil in the crankcase, bench tests being made in a four-cylinder water-cooled Morris 8 engine. From the point of view of wear and oil consumption, both synthetic oils were definitely superior to a standard commercial reference oil, oil 1 being superior to oil 2 in both respects. In the case of cylinder deposits both oils are inferior to the reference oil. The acidity, increase in carbon residue and increase in viscosity of all oils after use are very similar.

Alternative Fuels for Motor Transport. (H. Latour, La Science et la Vie, No. 276, June, 1940, pp. 574-593.) (79/27 France.)

The commercial transport engineer is mainly interested in those alternative fuels which require the minimum of alteration to his power plant. If the latter is of the spark ignition type, compressed coal gas forms the simplest solution. There is practically no alteration to the engine, the power output being, however, down by 25 per cent. (By raising the compression ratio and fitting a supercharger, this power drop can be made good, at the cost, however, of a certain amount of complication.) From the point of view of transport 1 cubic metre of coal gas (at N.T.P.) is roughly equivalent to 500 cc. of petrol (35 cubic foot $\approx$ 1 pint). If the vehicle is therefore to go any distance, a considerable quantity of gas will have to be carried. The commercial pressure bottles are charged up to 200 atmospheres, contain about 100 cubic feet of gas and weigh about 100 lb. (*i.e.*, 1 lb. per cubic foot of free gas). Recently pressure bottles made of light alloy reinforced with piano wire have been made, which weigh as little

as 1 lb. per 25 cubic feet of free gas. Such bottles are, however, not yet generally available and it is clear that the great weight of the commercial bottles render installation in a separate trailer necessary. (Liquid propane or butane gas presents many advantages over coal gas for transport purposes. Unfortunately it is not available in sufficient quantities in either Great Britain or France.) Next to coal gas, producer gas (generally made from charcoal) forms a possible substitute fuel and the author reviews several types of mobile producer plants which have been tried in France. Here again the general concensus of opinion favours the installation of the generator in a separate trailer.

New Type of Petrol Storage Tank. (V. Rubor, La Science et la Vie, No. 276, June, 1940, p. 634.) (79/28 Italy.)

An Italian engineer (E. Miozzi) has devised a brick built storage tank in which the petrol is stored above the surface of the water. The amount of metal required in the construction is less than one-third that required in normal steel tanks and there is no possibility of any petrol being lost either by evaporation or leakage. In principle the storage tank consists of a U-tube, the two limbs of which are of very unequal dimensions. Petrol is introduced into the wider limb, the other limb being filled with water. The wider limb is surrounded by a water bath contained in a brick structure. The level of this bath is above the petrol level in the limb so that any leakage can only be in the form of water into the petrol and not vice-versa. Any water entering would pass through the stored petrol and be detected by a change of level in the narrow limb.

It is stated that this method of storage has given excellent results.

Research on Surface Finish. (Schlesinger, Mechanical World, 19/4/40, p. 354.) (79/29 Great Britain.)

This continuation of the series on instruments for measuring surface finish gives an account of a Zeiss instrument, which consists of a microscope and a source of light set at right angles to one another. The image seen is a reflection from the surface of the work at right angles to the feed lines, and at 45° to the surface. The actual measurement depends on the adjustment of a micrometer screw, which moves a hair line from the crests to the roots of the surface. The series will be concluded in the next issue. Illustrated with one photograph and three diagrams. (Abstract supplied by Metropolitan Vickers Research Department.)

Ideal and Practical Navigation. (W. Immler, Luftwissen, Vol. 7, No. 1, Jan., 1940, pp. 3-9.) (79/30 Germany.)

Navigation is a form of applied geometry and position finding on the earth's surface can be carried out with extreme accuracy provided the necessary instruments are available and the conditions under which the observations are carried out are suitable. If the observer is stationed on the ground, the instruments can be protected from outside disturbances and conditions are practically ideal. As soon, however, as the observer is forced to take readings whilst he is in motion considerable sources of error may arise. On board ship the effects of motion can be allowed for to a considerable extent and the resultant navigation is still very accurate. In the case of aircraft, however, the observation platform undergoes continuous oscillations which affect both the magnetic compass and any artificial levelling device. On board ship it is possible to install gyro compasses which resist small disturbances and automatically return to the true north setting in a relatively short time. In aircraft, however, weight and space considerations necessitate much smaller instruments which, moreover, are subject to consider-

ably greater disturbances than can arise on board ship. As a result blind flying by instruments may cause position errors of the order of 5-10 per cent. of the distance from the last fix, and if it were not for the help given by wireless, blind flying over considerable distances would be clearly impracticable. The best results are obtained if so-called " homing " beams are available, spaced sufficiently close together so that the course setting is limited to ranges or the order of 500 km. over land. Such beams have the advantage that the accuracy of the fix increases as the objective is approached.

Fairchild Solar Navigator. (Inter. Avia., No. 709, 7/5/40, p. 7.) (79/31 U.S.A.)

The instrument consists of two principal parts, a sun compass head and a gyroscopically stabilised drift sight. By adjusting the compass head so that it points north (or south) in space and making a few other settings, all of which require but a few minutes, the instrument is ready for operation. To fly a perfectly straight course the pilot has merely to maintain a zero indication on a small galvanometer type left-right indicator which is actuated through photo-electric cells in the compass head. The photographer periodically checks the drift sight to be certain that ground images are tracking parallel to the drift line on the instruments ground glass screen. In this way flight strips of 50 miles or longer may be flown perfectly straight regardless of wind changes, magnetic variations or other troublesome factors encountered in photographic flying. Extreme accuracy in the overlap of photographs in a given strip is obtained with the instrument; the Navigator is also valuable as an aid in establishing a net work of triangulation over difficult terrain.

A Study of Knocking in Otto Engines by Means of Electro-Acoustic Measuring Devices. (A. W. Schmidt and K. Generlich, Deuts. Kraftfahrtforsch., No. 33, 1939, 15 pp.) (79/32 Germany.)

An electro-acoustic method for measuring the knock intensity is described, in which the noises received by the microphone are amplified and converted into optical signals by means of a Braun tube. The range of amplitudes obtained with these oscillograms covers all intensities of knock originated by the motor fuel. Since the apparatus is not in immediate communication with the combustion chamber, no drilling of bores in the cylinder head is necessary, and knock measurements can be made in any one of the cylinders of a multiple-cylinder engine with a single set-up. It has been found that individual differences in the fuel supply on the suction stroke, slight differences in the ignition timing and configuration of the cooling jacket around each cylinder account for individual differences in the octane number determined for the various cylinders.

The Lagometer. (Bryan, Electrical Engineer, 24/5/40, pp. 76-7.) (79/33 Great Britain.)

The lagometer has been designed by Siemens Bros. and Co. for measuring time constants of relays. It is an instrument for measuring very short intervals of time, and is similar in principle to the millisecond meter, both depending on the rate of charge or discharge of a condenser. This instrument, however, measures voltage as against quantity of electricity, and permits the use of a null method. A robust volt meter may thus be incorporated in the instrument, which is a portable one. The standard design is used with a nominal voltage of 50 v. with a variation of 8 v. either way, and the instrument is calibrated in three ranges of milliseconds. Illustrated with two photographs and two diagrams. (Abstract supplied by Metropolitan Vickers Research Department.)

Instrument Landing System for Aeroplanes. (Jackson, Alford, Byrne and Fischer, Electrical Communication, April, 1940, pp. 285-302.) (79/34 Great Britain.)

The preliminary section of the article deals with the development of instrument landing for aircraft. The remainder of the article discusses the Indianopolis instrument landing installation and suggests some sharper specifications than those of the Radio Technical Committee of Aeronautics. Four separate landing elements are advantageous, a localiser for lateral guidance, a glide path for descent, and two markers to indicate the progress along the path thus determined. It is claimed that the two-course localiser is the simplest form, and the importance of purity of polarisation is stressed. The ground and aeroplane transmitting and receiving instruments are described in detail. Illustrated with five diagrams and 13 photographs. (Abstract supplied by Metropolitan Vickers Research Department.)

Investigations of the Damage Lines in the Case of Light Metals. (G. Gurtler, Z. Metallk., Vol. 32, No. 2, Feb., 1940, pp. 21-30.) (79/35 Germany.)

Increased attention has latterly been paid to the end of the Wohler curve corresponding to low numbers of load cycles, a region characterising the " time " strength of metals. The processes taking place in this region before fracture occurs, which may either improve or decrease the ultimate fatigue strength, are of special interest. The curve limiting the region in which reduction of ultimate fatigue strength occurs before fracture is defined as the " damage " line (Schadenslinie). This curve has been investigated for an Al-Mg cast, and malleable alloy in various conditions by rotary bending tests. In the time strength region the damage line denotes the occurrence of cracks, noticeable in a decrease in impact strength, a reduction in alternating strength and an increase in bending deflection. Observation of the bending deflection curve provides a simple method for determining the damage line.

For the following materials:—Al-Si- refined, cast, annealed, Al-Si-Mg cast tempered, Al-Cu-Mg and Mg-Al, the damage line joins the Wohler curve approximately in the region of 20-30 million load cycles, while in the case of Al-Si- unrefined and refined in the cast state, and for homogenised cast Mg-Al it is still below the Wohler curve in the region of 100 million load cycles. Examples show that heat treatment has a considerable effect on the position and shape of the Wohler and damage lines. For the purpose of observing bending deflection an automatic measuring apparatus has been designed, having a magnification of 3,200: this makes it possible to easily detect the appearance of cracks in both plain and notched bars.

The Cause of Welding Fissures in Aircraft Steels. (J. Muller, L.F.F., Vol. 17, No. 4, 20/4/40, pp. 97/105.) (79/36 Germany.)

The fissures or cracks considered in this article occur between the weld proper and the underlying steel, the surface of the weld appearing perfectly sound. The trouble assumed rather alarming proportions in 1933, when German aircraft constructors adopted welding on a larger scale. Intensive investigations were at once undertaken covering not only the welding technique, but also design and materials. It was soon found that the principal reason for the cracks was an excessive sulphur content of the steel. This applies equally to plain carbon and alloy steels. The steels at present employed in Germany are prepared in electric furnaces and the chemical composition is very accurately controlled. As a result the product is free from accidental impurities and very homogeneous and can be welded without giving rise to any of the troubles mentioned above.

Effect of Fatigue on Impact Strength. (A. M. Portevin, Metal Progress, Vol. 37, No. 5, May, 1940, pp. 563-564. Review of French Experiments.) (79/41 France.)

In practice, two kinds of fracture are of special importance: Fatigue failures and brittle fractures. The former are generally characterised by a dull smooth surface, and resistance to fatigue is measured in lengthy and therefore expensive tests, during which the specimen is subjected to alternating stress cycles of known magnitude. Many attempts have been made to connect this endurance limit with the ultimate tensile strength and yield point of the material, which characteristics can be obtained in a few minutes. These attempts have not been successful, due no doubt to the fact that the material undergoes profound changes in the course of an extended series of load cycles. It appears at first sight that changes of this nature might develop brittleness by " crystallisation of the metal " and thus decrease impact strength, since impact fractures are generally coarsely crystalline. In order to settle this point, small impact specimens (7 × 7 mm. cross section, 55 mm. long and with a 2 mm. notch) were cut out of the root portion of fatigue test pieces of the rotary bending type. The following table shows that, contrary to expectation, the impact strength is not materially affected by fatigue in the case of an alloy steel of this type. C 0.25 to 0.30 per cent. Ni 4 per cent., Cr. 1.5 per cent., Mo 0.5 per cent.

No. of cycles endured.	Stress section at notch. (kg./mm.^{2}).	Impact strength (kg./m. per mm.^{2}).
0	0	10.0
2.6×10^6	54.6	11.2
16.8×10^6	52.5	10.2
6.0×10^5	50.8	11.2
1.5×10^6	50.8	11.2
12.5×10^6	50.8	11.2
1.5×10^5	50.3	11.7
11.3×10^6	50.3	11.7

Further experiments of steels of different composition treated in various ways are required before this conclusion can be accepted as being generally valid.

Tools and Speeds for Machining Aluminum Alloys. (W. A. Dean, Metal Progress, Vol. 37, No. 5, May, 1940, pp. 553-558.) (79/39 U.S.A.)

Aluminum alloys can be classified under the following main headings:—

(*a*) Non-heat-treated casting alloys.
(*b*) Heat-treated casting alloys.
(*c*) Heat-treated wrought alloys.
(*d*) Non-heat-treated wrought alloys.

Members of each of the above classes can be further sub-divided into types (I, II, III), depending on whether the machining qualities are " excellent," " good " or require special care. In a previous article by the same author (Metal Progress, Vol. 37, No. 2, Feb., 1940, pp. 169-173) about 40 commercial alloys in general use in the U.S.A. are listed in this manner. Type I alloys belonging to class (*a*) have the finest machining properties. No lubricant or cooling is required and relatively small cutting angles can be employed. Type II alloys necessitate large rake and clearance for successful machining, the metal chips being removed by shear rather than by tearing. In the case of heat-treated casting or wrought alloys of Type III the tool wear may become excessive unless cemented carbide tips are used. Particulars as to requisite tool dimensions for turning, milling and planing are given (clearance, cutting angles and rake).

The author also considers the operation of drilling, tapping and reaming. Data on cutting speeds are summarised in the following table:—

Cuts, Speeds and Feeds when Machining Aluminium Alloys.

	ROUGH MACHINING.			FINISH MACHINING	
	Cut (in.)	Speed (ft. per min.)	Feed (in.)	Cut (in.)	Speed (ft. per min.)	Feed (in.)
Lathe Turning—						
Type I. castings, not heat treated	<0.25 (a)	500 to 900	0.020 to 0.030	0.002 to 0.010	Maximum	0.002 to 0.010
All others	$<\frac{3}{16}$	400 to 800	0.007 to 0.020	0.002 to 0.010	600 to 900	0.002 to 0.010
Milling—						
Type I. castings, not heat treated	<0.25	400 to 600 (b) 500 to 700 (c)	5 to 15 (e)	0.010 to 0.020	500 to 700 (b) 500 to 700 (c)	10 to 25 (e)
Type I. castings, heat treated Type II. castings. Types I. and II. wrought alloys, heat treated	<0.25	Maximum (d) (for milling all alloys except Type III.)	4 to 10 (e)	0.010 to 0.020	Maximum (d) (for milling all alloys except Type III.)	5 to 15 (e)
Type III. alloys	<0.25	300 to 500 (b)	3 to 8 (e)	0.010 to 0.020	500 to 700 (b)	4 to 10 (e)
Boring—						
Light duty (1in. to 2in.)	$<\frac{3}{32}$ (a)	Maximum (f)	0.010 to 0.020	0.010 to 0.020 (a)	Maximum (f)	0.001 to 0.005
Medium to heavy duty	$<\frac{1}{4}$ (a)	600 to 1000	0.007 to 0.015	0.010 to 0.020 (a)	600 to 1000	0.001 to 0.003
Shaping—						
Heavy duty (36in.)	<0.25	Maximum (g)	0.010 to 0.030	0.005 to 0.010	Maximum (g)	0.100 to 0.150
Planing.	$<\frac{3}{8}$	Maximum (h)	0.025 to 0.100	0.005 to 0.015	Maximum (h)	0.050 to 0.375

NOTES—(a) Cut measured on radius.
(b) For carbon steel tools.
(c) For high speed steel tools.
(d) For cemented carbide tools.
(e) Travel of work.
(f) Peripheral speed of tool is maximum of most machines.
(g) Travel of ram.
(h) Speed of table.

Plastic Yielding and Fatigue of Ductile Metals. (R. W. Bailey, Proc. Inst. Mech. Engs., May, 1940, pp. 101-7.) (79/37 Great Britain.)

The author discusses methods of judging plastic yielding and fatigue of ductile metals, and indicates the need for a general criterion. This he proceeds to develop from a hypothesis of surface anisotropy of an otherwise isotropic material. The expressions obtained, when used with test results of direct and shear stress fatigue, enable limiting fatigue stresses of any combination of shear stress and direct stress in phase to be calculated. This in phase condition is taken as the most severe one, and the author comments on the influence of static shear stress on the maximum safe alternating direct stress.

Illustrated with nine graphs and diagrams and one table. (Abstract supplied by Metropolitan Vickers Research Department.)

Fatigue Testing of Welded Joints. (Hruska, Iron Age, 16/5/40, pp. 33-7.) (79/38 Great Britain.)

The author discusses the fatigue testing of welds with a view to more uniform testing and greater accuracy of interpolation. He puts forward suggestions for a testing machine which may be used for testing in both longitudinal and transverse directions, and he describes the cutting, position and finish of the test-piece. The machine is a modification of the cantilever type of apparatus, and is designed for flat specimens; great consistency of results is claimed.

Illustrated with five photographs, four diagrams and three graphs. (Abstract supplied by Metropolitan Vickers Research Department.)

Die Manufacture and Stretching Press for Aircraft Sheathing. (R. B. Gray, Metal Progress, Vol. 37, No. 5, May, 1940, pp. 559-561.) (79/40 U.S.A.)

The Glenn L. Martin Co. have recently introduced two interesting devices for the production of aircraft sheathing. The first consists of an entirely novel stretching press fitted with two hydraulic cylinders placed beneath a platen between two rows of independent clamp jaws. The cylinders are attached to the platen in such a way that the latter moves vertically and an angular position may be obtained if required. The sheet of metal to be stretched is placed over a former which in turn is resting on the platen, the sheet being held firmly in the rows of clamps placed on either side. As the platen moves up under hydraulic pressure, the sheet stretches until it follows the contours of the former or die, the reduction in thickness being usually of the order of 5-7 per cent. The form blocks used are made of wood covered with a very thin sheet of deep drawing body steel. Since, in the case of Dural, there is little or no spring back, the former can be made of the exact contour required. The press is mainly intended for the forming of large sheets such as skins and engine cowlings and much time is saved compared with the older method of bumping in a power hammer or forming under a drop hammer. Forming by stretching seems to be a happy medium between these slower operations and the high production methods used in the automobile industry requiring expensive dies and very powerful presses. In the latter case the die is usually of metal, and the second innovation introduced by Glenn L. Martin concerns a furnace for melting the zinc alloy of which the dies are usually made. The new furnace uses indirect heating by means of a lead bath which prevents pitting of the steel pots and produces a sounder die.

The Influence of Curvature on the Buckling Characteristics of Structures. (Th. von Kármán. J. Aeron. Sci., Vol. 7, No. 7, May, 1940, pp. 276-289.) (79/43 U.S.A.)

The prediction of the failing load of a thin walled structure with either simple or double curvature forms one of the most difficult problems of applied elasticity. At the moment, theory has to be supplemented with empirical relations based on

experiments and such a method of approach is always dangerous unless the designer has a clear physical picture of the problem.

The author first demonstrates that whilst the load on thin walled structures without curvature increases after buckling, the opposite holds good if the structure is curved originally. In the latter case, therefore, we have two critical loads, the " initial " or " upper " buckling load given by the classical theory and a " lower " buckling load which is the minimum load required to keep the shell in a buckled shape with finite deformations. If the specimen is geometrically perfect, buckling will start at the " initial " buckling load. As the deflection increases, the load diminishes. The elastic energy thus released will accelerate the buckling and the structure will finally oscillate (with heavy damping) about an equilibrium position corresponding to the " minimum " buckling load. Deviations from perfect geometrical shape will reduce the " maximum " load, but will generally have no great effect on the " minimum " load.

Besides the effect of initial deflection on the failing load of a thin shell the effects of vibrations occuring during the test must be considered.

Tensile Testing of Steels with Duplex Microstructure. (H. Hongardy, Metal Progress, Vol. 37, No. 5, May, 1940, pp. 565-566. Review of German Experiments.) (79/42 Germany.)

Variations in speed of the testing machine, within usual limits, have little or no effect on the results of the tension tests on plain carbon and alloy steels. The rate of loading has, however, an effect in the case of austenitic steels, especially if the latter lie in the transition range between austenitic and martensitic steels. As an example the following two steels are selected:—

	C.	Mn.	Cr.	Ni.	Structure.
(1)	0.15	16	9.8	0.7	Pure Austenite.
(2)	0.12	9.8	16.8	1.3	30 per cent. Ferrite.

STEEL No. 1.

RATE OF TESTING.

5 mm. per minute	Elongation, 53 per cent. Reduction, in area, 47 per cent.
90 mm. ,, ...	Elongation, 43 per cent. Reduction in area, 63 per cent.
25 mm. ,, ...	Yield strength, 42,500 lb./sq. in.
90 mm. ,, ...	,, 65,000 ,,

Ultimate tensile (140,000 lb./sq. in. only slightly reduced with increase of speed).

STEEL No. 2.

RATE OF TESTING.

5 mm. per minute	Elongation, 41 per cent. Reduction in area, 38 per cent.
90 mm. ,, ...	Elongation, 45 per cent. Reduction in area, 55 per cent.
5 mm. ,, ...	Yield strength, 56,000 lb./sq. in.
90 mm. ,, ...	,, 62,000 ,,

Ultimate tensile reduced from 135,000 lb./sq. in. to 118,000 lb./sq. in. with increase of speed.

These figures show that for alloy steels of this nature the speed of operation of the testing machine must be standardised.

Development and Production of the New Miniature Battery Tubes. (N. R. Smith and A. H. Schooley, R.C.A. Review, Vol. 4, No. 4, April, 1940, pp. 496-502.) (79/44 U.S.A.)

A new line of miniature battery tubes, including a converter, a radio frequency amplifier, a diode-pentode and a power output pentode has been made available. These new tubes are designed to operate efficiently on a 45-volt " B " supply with the filament operating directly from a single dry cell. The tubes are about two inches long and less than three-quarters of an inch in diameter.

A feature of this new line of tubes is a decrease in size without an increase in cost. This is accomplished by using a simplified envelope design which in the majority of cases permits standard size electrodes to be assembled using conventional manufacturing procedure. A new button stem in which the external leads serve as base connections contributes materially to the reduction in tube dimensions.

The small size and efficient operating characteristics of the new miniature tubes make them especially applicable to compact communication equipment as well as portable broadcast receivers. Also they may find application in special fields and such as hearing aids, meteorological service, or other places where size and weight are a consideration.

Preliminary Investigation of the Effects of Wave Polarisation and Site Determination with the Portable Ultra-High-Frequency Visual Radio Range. (J. M. Lee and C. H. Jackson, Civil Aeronautics Authority, Report No. 9, Feb., 1940.) (79/45 U.S.A.)

This report describes an investigation made to determine the effects of horizontal and vertical polarisation on ultra-high-frequency radio range transmission, and to establish general site requirements for the installation of this equipment. Particular attention is devoted to the effects of polarisation on the multiple course phenomenon. A description of the portable equipment used in the investigation is included. Copies of actual recordings taken during tests with transmission both from an open field and immediately adjacent to sources of reflection are also included in the report. It is concluded that site requirements are much less severe with horizontal polarisation than with vertically polarised transmission.

The Use of Hydraulic Power. (Town, Proc. Inst. Mech. Engs., May, 1940, pp. 129-41.) (79/46 Great Britain.)

In the course of this paper the author reviews developments in the utilisation of hydraulic power in machine and engine work. Synthetic plastics have opened a new field for the hydraulic press and hydraulic power is suited to the rapid production of dies for pressed work. Hydraulic power is finding increased application in automobile work for automatic gear changing, improved braking, lifting equipment and shock absorbing apparatus. In aeroplane work the reliability of hydraulic actuation has resulted in its application to a large amount of control gear. For the control of certain types of machine tools, textile machinery and ships' machinery, hydraulic power presents many advantages.

Illustrated with 12 diagrams. (Abstract supplied by Metropolitan Vickers Research Department.)

Intense Combination—Tones Produced by the Flutter of an Airscrew. (J. Obata and Others, Aer. Res. Inst., Tokyo, Rept. No. 187, Jan., 1940.) (79/47 Japan.)

The flutter of an airscrew is accompanied by a sudden and remarkable increase in the sound emitted In addition to the sound of rotation and torsional vibration, combination tones arise which, moreover, are of special interest since they

actually exist in the highly disturbed air and are not, as is usually the case, produced subjectively in the ear of the observer.

The light alloy airscrew used in these experiments was approximately 3 m. diameter and driven by an electric motor. The microphone (ribbon or velocity type) was placed at a distance of about 25 m. from the centre of the screw at 60° to the (theoretical) direction of travel of the screw and 1.7 m. above the ground. Frequency analysis was carried out by the usual methods. For the relatively thick blades utilised in the present experiments, the flutter is mainly due to torsional vibrations of the propeller (frequencies 315 and 575 vibrations/sec.) together with combinational tones produced by interaction with the sound of rotation. Under flutter conditions, the blade edge underwent displacements of the order of 1-2 cm. and the noise is stated to " baffle all attempts at description."

LIST OF SELECTED TRANSLATIONS.

NOTE.—Applications for the loan of copies of translations mentioned below should be addressed to the Secretary (R.T.P.), Ministry of Aircraft Production, Harrogate, Yorkshire, and copies will be loaned as far as availability of stocks permits. Suggestions concerning new translations will be considered in relation to general interest and facilities available.

Lists of selected translations have appeared in this publication since September, 1938.

MISCELLANEOUS.

TRANSLATION NUMBER AND AUTHOR.		TITLE AND JOURNAL.
1023	Richter, W. ...	*Flight Path and Control during Longitudinal Motion of an Aircraft.* (Ing. Archiv., Vol. II, No. 1, Feb., 1940, pp. 24-36.)
1034	Theile, U.	*Wireless Altimeters.* (L.F.F., Vol. 16, No. 6, 20/6/39, pp. 339-47.)
1035	Streltsov, V. ...	*Effect of Acceleration on the Human Organism.* (Aeroplane, U.S.S.R., No. 10, October, 1938, pp. 28-31.)

MATERIALS AND ELASTICITY.

1024	Esch, W. ... ... Nitsche, R.	*A New Test Method for Hardened Phenol-Formaldehyde Pressed Plastics for the Purpose of Analysis and Determination of Structure.* (Published by the Staatlichen Material prufungsamt Berlin-Dahlem.)
1031	Cicala, P.	*The Stressing of a Two-Spar Wing fitted with a Shear-Resisting Covering.* (L'Aerotecnica, Vol. 19, No. 1, Jan., 1940, pp. 3-26.)
1032	Marashini, G. ...	*The Shear Stress in a Hollow Section fitted with Arbitrary Stiffeners, with Special Application to Wing Structures.* (L'Aerotecnica, Vol. 19, No. 1, Jan., 1940, pp. 33-46.)

ABSTRACTS FROM THE SCIENTIFIC AND TECHNICAL PRESS.

Issued by the

Directorates of Scientific Research and Technical Development, Air Ministry.

(Prepared by R.T.P.)

No. 80. JULY, 1940.

The Mathematics of the Balloon Barrage. (Engineer, Vol. 169, No. 4,406, 21/6/40, pp. 549-551.) (80/1 Great Britain.)

Suppose n balloons flying at the same height are distributed round the circumference of a circle of radius r and S = span of attacking aircraft. Each wire being equivalent to a path obstruction of $2S$, the total obstructed path $= 2Sn$. Assuming further that the aircraft approaches at right angles to the line joining adjacent wires, the unobstructed path $= 2\pi r - 2Sn$. The degree of protection afforded to the area inside the circle

$$= 2Sn / (2\pi r - 2Sn) = 1 / (\pi r / Sn - 1) = \rho \quad . \quad . \quad . \quad (1)$$

For medium bombers S can be taken = 50 feet. Assume $\rho = \frac{1}{2}$, *i.e.*, out of three aircraft attempting penetration, two succeed and one fails. Substituting in (i) we obtain $2\pi r / n = 300$ feet = average distance between balloons, whatever radius of circle. The chance of a safe return of the aircraft (double penetration of barrage) is given by $1 / \{ \rho (\rho + 2) \}$ and with $\rho = \frac{1}{2}$, this reduces to 4/5. Thus out of nine aircraft approaching the barrage, three will be brought down on entering and two on leaving the protected circle, the remaining four escaping unhurt.

For a given number of balloons, it does not pay to have an outer ring surrounding the target ring proper. If, however, the target does not require uniform protection all over, some of the balloons can be concentrated with advantage on an inner ring surrounding the most vulnerable part. Thus 12 rings of balloons each giving by itself a degree of protection $\rho = \frac{1}{16}$ (distance apart 1,700 feet) would give, taken together, a one to one protection to the innermost ring, *i.e.*, out of four machines attacking, three would probably be brought down either while entering or escaping from the barrage.

Theoretical Internal Ballistics. (R. Winter, Mémorial de l'Artillerie Française, Vol. 18, Part 4, 1939, pp. 775-862. Available as R.D. Trans. 895.) (80/2 France.)

During 1938-9, Winter gave a course of lectures on ballistics at the School of Naval Artillery covering the following aspects of the subject:—

1. Theoretical internal ballistics.
2. Application of theory and methods of numerical calculation.
3. Measuring instruments.
4. Applied ballistics.

Part 1 of this course was divided into four sections dealing respectively with

(*a*) Physical and thermodynamical foundation of equations.
(*b*) The theory of ballistic similarity.
(*c*) Charbonnier-Surgot theory.
(*d*) Historical review and present position of the problems.

The present article deals with section (*a*) of Part 1 of the course only, but it is hoped to publish sections (*b*), (*c*) and (*d*) subsequently. The treatment follows the usual lines and does not depart materially from that adopted by the standard text book of Cranz (Vol. 2).

The following are some of the main points covered:—

1. Energy equation, including motion of gases.
2. Characteristics of standard explosives.
3. Mechanism of combustion.
4. Closed vessel experiments.
5. Relationship between percentage of charge burnt and pressure realised.
6. Charbonnier equation for rate of burning.

Light Alloy Visors. (Light Metals, Vol. 3, No. 30, July, 1940, p. 173.) (80.3 Great Britain.)

The visor, which consists of a perforated sheet of duralumin attached to a steel helmet, is equipped with a spring device which enables it to be kept within the helmet and to be lowered with ease when required.

In tests with a 12-bore shot gun, it was found that no penetration occurred at distances of 30 yards, whereas the unprotected eye would be destroyed at twice this distance.

Between 1914 and 1918 approximately 2,000 men were blinded in both eyes and 40,000 in one.

Fuses for Anti-Aircraft Shells. (A. Kuhlenkamp, Z.V.D.I., Vol. 84, No. 18, 4/5/40, pp. 301-305.) (80/4 Germany.)

Anti-aircraft shells are fitted either with time or impact fuses. Time fuses may be either of the chemical or mechanical type. The chemical fuses are cheap to manufacture, but not very consistent in their behaviour, since the time of burning of the fuse depends on the temperature and pressure of the surrounding air as well as on the angular rotation of the shell. Moreover, the fuse deteriorates quickly on storage, and if the fuse has once been " set " it is impossible to reset it to give a longer time of burning.

For this reason, mechanical fuses (operated by clockwork) have come into general use and the author describes typical types (Swiss " Tavaro " fuse used in France and the German Krupp-Thiclen and Junghans fuses). Such mechanical fuses present interesting engineering problems. Not only must the mechanism measure time intervals up to 30 seconds with an accuracy of 1/10 sec., but it is subject to very high linear (27,000 g. maximum!) and angular acceleration (mean value 150,000 radian/sec.^{2}) while passing through the gun barrel. In addition, the fuse must be fitted with a number of safety devices preventing premature explosion (either in the barrel or in the early stages of flight or when accidentally dropped).

Of the three types described, the Junghans is the simplest since the clockwork is operated by centrifugal action and no springs are required. Since, however, the centrifugal action decreases with time (slowing up of spin of shell) certain compensating devices are required in this design.

Whilst time fuses automatically explode after a certain interval, contact fuses only operate when they strike the target. In case of a miss, however, the projectile should explode on its down paths to prevent possible danger when striking the ground. A chemical time fuse is therefore fitted in addition to the

main fuse, but since very accurate timing is not essential, the problem is very much simplified.

The Bofors impact fuse is described and certain modifications introduced in Germany are briefly referred to.

A bibliography (eight references) concludes the article, which is illustrated with 10 diagrams.

Explosion Waves and Shock Waves VI. The Disturbance Produced by Bursting Diaphragms with Compressed Air (digest). (W. Payman and W. C. F. Shepherd, Proc. Roy. Soc., Vol. 175, No. 962, 12/6/40, pp. S 27-8.) (80/5 Great Britain.)

Experimental verification of the theoretical relationships governing the motion of shock waves has been derived from an investigation into the development of the disturbance set up in a uniform tube when a body of compressed gas, confined at one end by means of a copper diaphragm, is released by rupture of the diaphragm. The wave-speed camera has been used to obtain continuous Schlieren records of the passage of these effects along the tube and to analyse their properties under a variety of experimental conditions, the main variations being those caused by the use of different thicknesses of diaphragm, different lengths of compression and expansion chambers, and of different gases in these chambers.

Some Experimental Results of Aerofoil Tests in the Guidonia Supersonic Wind Tunnel. (A. Ferri, Atti di Guidonia, No. 17, 20/9/39.) (80/6 Italy.)

The object of the tests was to provide some experimental check of the aerodynamic theories relative to the supersonic field of velocities. The aerofoils to be tested were therefore chosen so as to allow a straightforward theoretical calculation of their characteristics; their profiles are built up of circular segments. Four different profiles (G.U. 2, 3, 4 and 5) were chosen and on all of them force measurements were taken; on two of them (G.U. 2 and 3) the pressure distribution was measured and optical flow investigations were also made. The pressure distribution curves were found most useful in that they explained the discrepancy between theory and experiment. All tests were carried out at two Mach Nos. 1.85 and 2.13.

Curves of C_D, C_L and C_M, against incidence are given for both Mach numbers for all the profiles tested. The pressure distribution curves have been plotted for a wide range of incidences, and the theoretical curves are given for comparison.

Whereas the occurrence of shock at and around the leading edge is in fair agreement with theory, the discrepancy between theoretical and experimental pressure distribution is very great for the rear portions of the profile.

The author's experiments indicate that in the supersonic field of velocities the boundary layer plays a very important part and that theories neglecting viscosity cannot explain the actual phenomena.

The Guidonia Aerodynamic Laboratory. (A. Eula, Atti di Guidonia, No. 13, 20/7/39.) (80/7 Italy.)

The laboratory is equipped with four 6.6 ft. single return open jet wind tunnels, all of identical design, intended more especially for routine tests. Each is equipped with a single fan, driven by a 330 kw. D.C. motor. The maximum speed is 229 ft./s. The same building houses a vertical tunnel for spinning tests, with a wind speed of 98 ft./s., and also several smaller tunnels, one of which is a high speed one, driven by a 180 h.p. motor. Intended mainly for research work, a high speed (328 ft./s.) 9.8 ft. double return, open jet tunnel is housed in a separate building and is driven by a 1,550 kw. D.C. motor. Another building

houses the supersonic tunnel, which is described in another report. The criterions which prompted the choice of the various types of wind tunnel are outlined.

The D.C. current for the driving motors is obtained by means of a C./D.C. transformer groups. The electric layout is described in detail, as also the various workshops and offices attached to the laboratory.

The Guidonia Supersonic Wind Tunnel. (A. Ferri, Atti di Guidonia, No. 15, 20/8/39.) (80/8 Italy.)

The tunnel is of the closed circuit variable density single return type, fitted with guide vanes at the corners. The circuit consists of (1) a 13-stage axial compressor delivering 1,588 ft.^{3}/sec.; (2) a 4-stage water refrigerator for cooling the air at the compressor exit; (3) a test section; (4) a return channel. The compressor is driven through a step-up gearing from a 2,820 h.p. D.C. motor, the current being supplied by an A.C./D.C. transformer group. Upstream of the test section, a by-pass is provided, which allows for adjustment of the quantity of air flowing through the test section, independently of the compressor. By means of an ejector device at the valve outlet it is possible to increase the pressure drop across the test chamber in order to attain even greater speeds. An electrically driven air pump is connected to the tunnel circuit, enabling the air pressure in the interior to be varied within the range of 0.1 at (absolute) to 4 ata. Thus the tunnel can either be exhausted for the attainment of higher speeds or it can be put under pressure to increase the Reynolds number when working at the lower speeds. The operation of the plant is made practically fool-proof by the provision of an elaborate system of relays and locking devices controlling oil circulation, water circulation and starter rheostat for the A.C. motor. To avoid any possible vibration of the measuring instruments during tests, the foundations of the rotating machines and of the tunnel are separate from those of the walls of the building and of the control board. In addition, a further precaution has been taken, by providing the floor with a special anti-vibrating beam, set at right angles to the tunnel, close to the test section, where the measuring instruments are normally placed.

Measurements and Analysis of the Motion of a Canard Aeroplane Model in Gusts. (P. Donely, H. B. Pierce and P. W. Pepoon, N.A.C.A. Tech. Note No. 758, April, 1940.) (80/9 U.S.A.)

A model (weighing 1.3 lb.) of a hypothetical canard aeroplane (weight 13,650 lb.) which was designed to be of the same size and general aerodynamic characteristics as a Boeing B-247 aeroplane, was tested in the N.A.C.A. gust tunnel at one wing loading, one forward speed, one gust velocity, and three gust gradients. The purpose of these tests was to determine the reactions of the model and to compare them with the results of unpublished tests on an equivalent model of the Boeing B-247 aeroplane.

It appears that the resultant acceleration increment for the canard model was much higher than that for the Boeing B-247 model. The analysis indicated, however, that the stabiliser loads on the canard model accounted for the difference so that the aerodynamic loads on the wings of the two models were approximately equal. Thus, although the acceleration increment and the stabiliser load on the canard model are higher than those on the corresponding conventional arrangement, the net wing load on the canard model appears to be smaller by virtue of the greater inertia load acting to oppose the aerodynamic load.

A Full-Scale Investigation of the Effect of Several Factors on the Shimmy of Castering Wheels. (W. B. Howard, Jr., N.A.C.A. Tech. Note No. 760, April, 1940.) (80/10 U.S.A.)

A full-scale investigation has been conducted to determine the effect of various factors on the shimmy of castering wheels. The factors considered were the

geometric arrangement, the tyre types, the variations of load, the spindle moment of inertia, and the tyre inflation. A comparison of the results of the present investigation with those calculated from existing theory was made. The constants needed in the calculations to determine the damping required for a castering wheel were measured.

The results indicate that solid friction appears to be impracticable as the sole damping agent for castering nose wheels on large aeroplanes. Also it was concluded that the existing theory is adequate for calculating the damping required to prevent shimmy. The caster angle and the spindle moment of inertia were found to influence the solid friction required to prevent shimmy. The effect of variations in the type and the pressure of the tyre was insignificant.

Stability of Castering Wheels for Aircraft Landing Gears. (A. Kantrowitz, N.A.C.A. Report No. 686, 1940.) (80/11 U.S.A.)

A theoretical study has been made of the shimmy of castering wheels. The theory is based on the discovery of a phenomenon called kinematic shimmy. Experimental checks, use being made of a model having low pressure tyres, are reported and the applicability of the results to full scale is discussed. Theoretical methods of estimating the spindle viscous damping and the spindle solid friction necessary to avoid shimmy are given. A new method of avoiding shimmy—lateral freedom—is introduced.

The Stressing of Girder Fuselages. (C. Riparbelli, Atti di Guidonia, No. 5, 15/4/39.) (80/12 Italy.)

Various practical methods of stressing fuselages of the girder type are described, with a view to providing the designer with rapid means of calculation. The advantages of stressed skin versus steel tubing construction for fuselages are discussed and it is concluded that the steel tubing type is not likely to be superseded in the near future, the stressed skin offering advantages only for mass production, and for fuselages with only a few openings for cockpits, turrets, etc.

The loads imposed on the fuselage, namely, (1) bending load in the vertical plane, (2) bending load in the horizontal plane, (3) torsional load, are analysed. Stressing the fuselage for the first two types of load is relatively easy, and is usually done by means of force polygons, assuming the struts to be hinged at their extremities. A procedure for the determination of distribution of load between the faces of the girder structure is outlined. The torsional stressing, however, although not difficult in itself, can be very tedious, because, owing to the diagonal bracings, the problem is usually statically redundant.

Three methods of torsional stressing are described. The first method, well known, is an accurate one, and is based on the principle of minimum work of deformation. However, the calculations are so involved, that in practice it can only be used for the final check up after the dimensions have been determined by other means. The second method given is approximate, but much more rapid. It reduces the redundant system to one which is statically determined. This method is named " isostatic," and it derives from the author's suggestion to stress the fuselage by the same criterion on which are based the Bredt equations for the torsional stressing of thin-walled hollow cylinders, and is, therefore, based on the same assumptions as those on which Bredt's theory is founded. The last method, also approximate, treats the structure as redundant, but is also relatively rapid; the fuselage is split into sections, each of which is separately stressed under the assumption that the boundary conditions are such as to hold it in equilibrium. This method is also advisable as a check for the sections adjoining the wing and tail unit, when the " isostatic " method has been used.

The Vertical Wind Tunnel for Spinning Tests. (A. Vannucci and V. Ciampolini, Atti di Guidonia, No. 23, 10/3/40.) (80/13 Italy.)

The tunnel is of the single return type, with a circular test section of 9.8 ft. diameter. Eight sets of guide blades are fitted at different points in the circuit, their position having been determined experimentally so as to give a uniform flow in the test section. The wooden fan-propeller has six blades and is followed downstream by a six-bladed stator. The propeller shaft runs horizontally in the upper section of the tunnel circuit, the D.C. driving motor of 150 h.p. being mounted on a bracket outside. Current is supplied by a Ward-Leonard A.C./D.C. transformer group, to which a field dynamo for both the D.C. motor and generator is coupled. The ratio of kinetic energy in the stream to the power output of the motor is 1.74 and the maximum wind velocity 112 ft./s. The turbulence in the stream is 180,000 ($=R_e$ at which 10 in. sphere has a drag coefficient of 0.15).

After various devices had been tried the models are now launched by hand. A brief review of the methods of manufacture used in the models is followed by a description of the balancing procedure and of the methods used to determine and adjust the moments of inertia so as to achieve dynamic similarity.

Two types of routine tests are carried out at present; for the study of the steady spin, and for that of the behaviour at recovery. In the former tests, a cinematograph film, on which a time base is also recorded, is exposed at the rate of 40 to 60 frames per second, for a duration of 30″ to 60″. The rate of spin, its radius and the inclination of the longitudinal axis of the model are deduced from these records. The second type of tests is merely qualitative; the character of the recovery is noted and the number of turns made by the model after setting the recovery controls (by clockwork) are noted.

In order to study the unsteady conditions preceding the spin more fully, an experimental technique has been developed for launching the model in free air from a considerable altitude (1,000-1,300 feet) by means of a kite balloon.

The controls in the aircraft model are moved by means of clockwork according to any predetermined law. A parachute is released as the model approaches the ground in order to prevent accidental damage.

Friction and Temperature as Criteria for Safe Operation of Journal Bearings. (S. A. McKee, Bur. Stan. J. Res., Vol. 24, No. 5, May, 1940, pp. 491-508.) (80/14 U.S.A.)

This paper describes a method for the application of friction and heat dissipation data to the determination of the load-carrying capacity of a journal bearing when operating with a lubricant of known characteristics. This method depends upon two considerations: First, that the bearing shall operate in the region of stable lubrication; and second, that the operating temperature shall not exceed some limiting value.

The relationship between the thermodynamic and hydrodynamic factors pertaining to journal bearing lubrication is given by an equation for thermal equilibrium. From this relation, pressure speed curves representing the limits for safe operation for a given bearing with a given lubricant are obtained by consideration of permissible values for temperature rise and the operating variable ZN/P, where Z is the viscosity of the oil, N the speed of the journal, and P the bearing pressure.

An example of the application of this method is given, using friction and heat dissipation data obtained experimentally in laboratory apparatus with bearings and lubricant typical of some automotive installations.

Mechanically Driven Superchargers. (R. S. Buck, J. Aeron. Sci., Vol. 7, No. 8, June, 1940, pp. 334-9.) (80/15 U.S.A.)

There are two major problems involved in the development of mechanically driven superchargers; first, the problem of building a machine which will be as

efficient as possible, and second, the problem of making this machine fit the operating characteristics of the engine.

The design of a supercharger requires a thorough knowledge of what happens in each part of the supercharger itself, and this knowledge can be obtained only by test.

Supercharging development is handicapped by a general lack of information regarding the characteristics of internal combustion engines when operating at high altitude.

Although superchargers can be developed by building and testing the completed machine on the bench and then on the engine, it is a slow, crude and wasteful method. There is a vital and urgent need, if the supercharger is to be used to its utmost, for a major research problem.

A Property of the Crank, Connecting-rod and Piston Mechanism and its Applications to the Master- and Articulated-rod Mechanism. (L. Crocco, Atti di Guidonia, No. 4, 1/4/39.) (80/16 Italy.)

In a crank, connecting-rod and piston mechanism, the motion of any point of the connecting-rod can be regarded as the resultant of two superimposed motions: The first is a simple rotary one around the axis of the crank, having always the same angular velocity as the latter; the second is a translational motion along a fixed straight line and is similar to the motion of the piston on its path, the axis of the crank being centre of similarity. Application of this property enables the author to deduce some simple graphic methods for the determination of both velocity and acceleration.

In the case of the master and articulated-rod mechanism, the motion of the piston belonging to the articulated rod can be regarded as resulting from the motions of two ordinary connecting-rod and crank mechanisms, the pistons of which move on the same path and the cranks of which are rigidly connected to the crank of the given mechanism, with which they rotate. One of the motions is in phase with that of the given mechanism, whereas the other is not, its crank being retarded relatively to the given one, by a fixed angle. This last quantity, the crank throws of the two mechanisms and the length of their connecting rods are obtained by simple geometrical constructions or from elementary equations, by calculation.

The Influence of Crystal Size on the Wear Properties of a High-Load Bearing Metal. (J. R. Connelly, Trans. A.S.M.E., Vol. 62, No. 4, May, 1940, pp. 309-18.) (80/17 U.S.A.)

A specimen of bearing material has one side machined to a plane surface. A constant holding force, hereafter referred to as the load, presses the machined surface tangent to a rotating steel cylinder, submerged in a bath of lubricant. For these tests the force was obtained by gravity. The specimen, which can move only in a direction normal to the machined surface, wears a cylindrical groove and the contact changes from line to a progressively larger area. This wearing away continues until equilibrium conditions are established between the forces causing wear and the forces resisting wear. The load divided by the projected area at any instant is referred to as the pressure, and the pressure existing at equilibrium is called the final or ultimate bearing pressure or equilibrium pressure. Rate of wear is designated as volume of bearing material removed per length of travel of a point on the surface of the cylinder.

CONCLUSIONS.

The results are evidence that, for the bearing metal tested, (*a*) crystalline structure is a factor and crystal size an important variable in thin-film lubrication, (*b*) rate of wear and equilibrium pressure are related, and (*c*) pressures at beginning and end of lubricated wear are related. The method of investigation used is a way of determining quantitative values of rate of wear, equilibrium

pressure, and the pressure at the borderline condition between unlubricated wear and lubricated wear. Other things being equal, a very small crystal size gives optimum values of rate of wear and equilibrium pressure.

Bearings that are poured in place, such as large pillow-block bearings, have crystal sizes in the range where the rate of wear and equilibrium pressure are decidedly not optimum. In the future, such large bearings could be better designed to make use of some type of insert that could be cooled rapidly upon pouring.

The Friction of Lubricated Metals. (F. P. Bowden and L. Leben, Phil. Trans. Roy. Soc., Vol. 239, No. 799, 27/6/40, pp. 1-27.) (80/18 Great Britain.)

An analysis has been made of the kinetic friction between metals sliding under conditions of boundary lubrication. With mineral oils and many other lubricants an intermittent clutching and breaking away of the surfaces still occurs through the oil film. The friction, the surface temperature and the area of contact all show violent fluctuations and the behaviour may be essentially the same as with unlubricated metals. Certain substances, however, are able to prevent this " stick-slip " motion and allow continuous sliding to take place. With short-chain fatty acids, for example, the motion is " stick-slip," but when the chain reaches a certain length continuous sliding occurs. Alcohols and saturated hydrocarbons of the same, or longer, chain length do not cause continuous sliding. Even with the best lubricant the film breaks down to some extent during sliding and some wear of the surfaces takes place. The metal is torn to a depth which is large compared with the dimensions of a molecule. The frictional force between lubricated metals must therefore be greatly influenced by the bulk properties of the metals concerned.

Prospects of Fuels of Higher Octane Number in the Transport Field. (W. H. Hubner, J. Aeron. Sci., Vol. 7, No. 8, June, 1940, pp. 319-332. With discussion.) (80/19 U.S.A.)

A few years ago, 80-83 petrol was standard for American air lines. Then came 87 and at the moment 90 octane seems to be the most popular grade. The next logical step appears to be the general adoption of 95 octane fuel. The exact make up of such a fuel will depend on the individual refiner, but it will in general consist of a base straight run or catalytically cracked fuel, a high octane blending agent or mixture of agents and tetra ethyl lead in amounts specified by the engine manufacturers. Since the blending agents are the most expensive constituents, it is probable that the maximum percentage of base gasoline will be used, the addition of tetra ethyl lead being limited to about 4 c.c. per gallon. The principal source of base spirit are the following:—

(*a*) Straight run, *i.e.*, obtained from crude oil by simple distillation.
(*b*) Natural petrol, extracted from oil well or casing head gas.
(*c*) Catalytically cracked or reformed petrol. This represents the most important source of base spirit for aviation fuels at the moment.
(*d*) Hydrogenated petrol, just entering on a commercial scale.

The most commonly used blending spirits are iso-octane and alkylates. (Isopentane and in some cases aromatics are employed as alternatives.)

Considerable space is given by the author to the consideration of so-called safety or high flash point fuels. Such fuels can be of either the aromatic or paraffinic type. Octane ratings of the order of 100 can be obtained (with the usual 4 c.c. of lead per gallon) and it is claimed that the cost of such a fuel would be comparable with standard volatile spirit of equivalent octane rating. The power output is the same, using pump injection in both cases.

The oil refiners of the United States have sufficient capacity to produce more 95-100 octane fuel (volatile type) than corresponds to the total aviation requirements, both military and civil.

High flash fuel is available in much smaller amounts, but supplies are adequate for pioneer work and substantial quantities could be produced if needed.

The main reason against the more general adoption of 100 octane fuel (apart from military use) is one of cost. At the moment the difference in cost between 87 and 100 octane is about 8-9 cents per gallon. The benefit to the air line operator (speed, increased range or load capacity) are estimated to be of the order of 6-7 cents per gallon (half cent per octane number). At the present moment, therefore, the higher octane fuel just fails to be an economic proposition.

With increased usage (including motor transport) it appears reasonably certain that the price handicap can be made to disappear. This will happen all the more readily the sooner fuel specifications are relaxed. These specifications are considered unduly stringent by the author.

An interesting discussion concludes the paper.

Boundary Film Investigations (with Discussion). (S. J. Needs, Trans. A.S.M.E., Vol. 62, No. 4, May, 1940, pp. 331-45.) (80/20 U.S.A.)

When two optically smooth plane steel surfaces are brought together in the presence of oil in such manner that the formation of a parallel film is possible, the distance between the surfaces will reach some definite minimum value depending upon the viscosity of the oil and the external force acting upon the surfaces. At room temperature, with surfaces $\frac{5}{8}$ in. diam., this minimum film thickness varies from about 30 $(10)^{-6}$ in. with olive oil to about 60 $(10)^{-6}$ in. with a heavy cylinder oil. The minimum film thickness is not greatly changed by loads up to 800 lb. per sq. in. of surface area.

The nature of this separating film is not known, but experimental evidence indicates that the proximity of the metal surfaces has a profound influence upon the forces normally acting between the molecules of the liquid. This gives the film a high degree of mechanical stability, as evidenced by its ability to support considerable load without radial flow. The film also assumes the curious property of directional rigidity which seems to depend upon the direction, rate, and duration of shear.

The Ignition Quality of Brown Coal Tar Oils for Diesel Engines. (R. E. Heinze, Z.D.V.I., Vol. 84, No. 21, 25/5/40, pp. 363-364.) (80/21 Germany.)

The ignition quality of Diesel fuels is stated by the author to be of outstanding importance for the engine rating of these fuels. This ignition quality is measured by the cetene or cetene number. Heinze and Marder use physical constants, such as boiling range and specific gravity or parachor ($\sqrt[4]{(\sigma)}/qM$ where σ = surface tension, q = density and M = molecular weight). With constant boiling range the cetene number increases linearly with the parachor.

Heinze and Schneider investigated the extent to which the ignition properties and yields of Diesel fuels, obtained by the distillation of brown coal tar, can be improved by varying the distillation pressure and found that:—

1. By distilling tar oil in vacuo (20 mm. Hg.) the density and boiling range increase with increasing temperature of distillation. The ignition quality also increases.

2. By distilling at atmospheric pressure the average cetene number increases by about 7 units owing to partial cracking of the higher paraffinic hydrocarbons. The resulting hydrocarbons of lower molecular weight decrease the density of the higher fractions.

3. By distilling at excess pressures of the order of 1 to 3 atm. the high-boiling paraffinic tar fractions (useless as Diesel fuels) are cracked. The yield and ignition quality are increased thereby.

4. By distilling at excess pressure of the order of 10 atm. the fractions in the boiling range of the Diesel fuel are also cracked and the yield and ignition quality of the Diesel fuel are reduced.

The best yields were therefore obtained by carrying out the distillation at pressures of the order of 2 to 3 atm.

An increase in the ignition quality and yield can also be obtained by the use of catalysts.

NOTE.—The parachor represents a comparison of molecular columns for liquids at temperatures at which they have the same surface tension.

A Modified Capacity Bridge for Airscrew Tests. (C. D. Smith, J. Sci. Inst., Vol. 17, No. 6, June, 1940, pp. 157-60.) (80/22 Great Britain.)

The use of the Maxwell Capacity Bridge for the measurement of rotational speeds has been developed for wind tunnel tests on airscrews. Airscrew performance depends on the wind speed V as well as the rotational speed n, being expressible as a function of the ratio of these two quantities. The deviation of the actual tunnel speed from its nominal value is determined by the prevailing atmospheric temperature and pressure, and its effect on the ratio V/n is arranged to be compensated for by means of additional resistances introduced into one of the ratio arms of the bridge and calibrated directly in degrees centigrade and inches of mercury. At high rotational speeds the charging of the condenser during each cycle may not be complete, but this difficulty is overcome by connecting a large capacity across the leads to the commutator.

A Convenient Electrical Micrometer and its Use in Mechanical Measurements. (R. Gunn, J. App. Mech., Vol. 7, No. 2, June, 1940, pp. 49-52.) (80/23 U.S.A.)

A simple electrical micrometer of great mechanical and electrical stability has been developed. The electrical current output from the micrometer is accurately proportional to the impressed mechanical displacement. The least count of typical micrometers using portable microammeters as indicators and employing no amplification is 5/1,000,000 in. zero drift, hysteresis, temperature, and pressure variations have been reduced to less than 1 per cent. Special circuits are described which permit the indication of the sums, differences, ratios, or products of mechanical displacements and hence are useful in many mechanical measurements. The micrometer is also convenient for zero and low frequency vibration studies.

The Automatic Maintenance of Load in Creep Testing. (G. A. Mellor and E. A. Jenkinson, J. Sci. Inst., Vol. 17, No. 6, June, 1940, pp. 155-6.) (80/24 U.S.A.)

A test piece is suspended from a steel frame and loaded through a lever arm which falls as the specimen elongates and is restored automatically to the horizontal by means of the apparatus described. As the lever arm falls an electrical contact is made permitting the passage of a current through solenoids mounted on a reciprocating shaft at the top of the frame. A pawl, also mounted on the shaft, is brought into operation by the solenoid and turns a ratchet wheel. The upper tension bar of the testing unit screws into a wheel which is connected by gearing to the ratchet wheel so that movement of the latter by the pawl raises the test piece and lever arm.

Relaxation Methods Applied to Engineering Problems. (A. Pellew and R. V. Southwell, Proc. Roy. Soc., Vol. 175, No. 962, 12/6/40, pp. 262-90.) (80/25 Great Britain.)

In this paper relaxation methods are applied to the difficult problem of determining the natural modes and frequencies of a system having restricted but

considerable freedom (*i.e.*, where the independent co-ordinates number 6 or more). A theorem published recently (Southwell, 1940) is used to impose lower limits on the wanted frequency, and upper limits are calculated on the basis of " Rayleigh's principle." In the " liquidation " process these upper and lower limits converge steadily, and when they have become closely coincident both the frequency and the associated mode (which Rayleigh's principle does not determine) are given with sufficient accuracy for all practical purposes.

An example treated in detail relates to undamped torsional vibrations or (by analogy) to transverse vibrations of a tensioned and loaded string. Concluding sections indicate some immediate extensions of the method.

Plastic Yielding and Fatigue of Ductile Metals. A Criterion and its Application. (R. W. Bailey, Proc. Inst. Mech. Engs., Vol. 143, No. 2, May, 1940, pp. 101-107.) (80/26 Great Britain.)

In the case of a metal which is isotropic not only in condition, but more especially under stress, the Mises-Hencky criterion should apply. If X, Y, Z are the components of three dimensional stress, we thus have $(X-Y)^2+(Z-X)^2+(Y-Z)^2=$constant under conditions of yield.

It appears reasonable to believe that on a grain boundary and in its immediate vicinity, conditions differ from those within the body of the grain. Consequently, if shear strain energy is a fundamental factor determining yielding, it is unlikely that the proportions contributed to the criterion by the boundary and the body materials will be the same. Assuming that yielding is initiated at or near the surface of a test piece, when the three principal stresses are X, Y, Z (zero) the energy criterion takes the form

$$(X-Y)^2+\alpha(Z-X)^2+\alpha(Y-Z)^2=\text{constant when } \alpha=\text{constant}.$$

This may be written in the form

$$X^2+Y^2-2XY/(1+\alpha)=\text{constant}$$

or $f^2+\{2(2+\alpha)/(1+\alpha)\}q^2=$constant, when q and f are the components of shear and direct stress respectively, f/q must thus fall in the range $\sqrt{2}$ (α large) and 2 ($\alpha=$zero).

Making use of direct and shear stress fatigue test results, the proposed criterion is applied to derive limiting fatigue stresses for the most severe conditions of combined shear and direct stress in phase with each other.

Analysis indicates that the presence of static shear stress may increase the ability of a steel to withstand reversing direct stress.

A Photoelastic Study of Stresses in Rotating Discs. (R. E. Newton, J. App. Mech., Vol. 7, No. 2, June, 1940, pp. 57-60.) (80/27 U.S.A.)

The recent experiments of Hetenyi and others in developing a technique for " freezing " stresses in bakelite and other photoelastic plastics have broadened tremendously the scope of the photoelastic method of stress analysis. In addition to making possible the solution of three-dimensional problems, the new technique offers itself as a powerful tool in solving problems in which it is inconvenient to study the fringe pattern while the model is actually under load. Problems of centrifugal stresses in constant-speed rotors fall in this class and are readily handled by the stress-freezing method. It is the purpose of this paper to discuss the application of the technique to the determination of the stresses in rotating discs of uniform thickness having symmetrically placed non-central holes.

A Rational Definition of Yield Strength. (W. R. Osgood, J. App. Mech., Vol. 7, No. 2, June, 1940, pp. 61-2.) (80/28 U.S.A.)

Explicitly or implicitly the yield strength of a material is often used as a measure of incipient structural damage. With the yield strength determined by conventional methods, however, it cannot be said in general for two structural

elements geometrically alike but of different materials that similar loads, producing maximum stresses equal to the yield strengths in the two cases, are simply related to the yield strengths. A definition of yield strength is proposed in this paper which often has the advantage that, for geometrically similar structures of different materials, loads producing maximum stresses equal to the yield strength are proportional to the yield strength.

Critical Speed Behaviour of Unsymmetrical Shafts. (H. D. Taylor, J. App. Mech., Vol. 7, No. 2, June, 1940, pp. 71-9.) (80/29 U.S.A.)

The first part of the paper deals briefly with the static characteristics of unsymmetrical shafts, as a basis for defining the " degree of dissymmetry." The critical speed behaviour of ordinary round shafts is then reviewed and the theoretical differences due to dissymmetry are described. These are: (*a*) With moderate dissymmetry compared with the degree of damping, a marked increase in the critical speed amplitude, and a pronounced variation in the amplitude with the angular position of the unbalance of the rotor; (*b*) with greater dissymmetry, beyond a limiting value, an infinite critical speed amplitude, or rather, two infinite peaks, with unstable operation between them; (*c*) considerable distortion of the phase angle curves, such that in general the phase angle may be much larger or smaller than 90 deg. at the critical speed; (*d*) double frequency vibration, if the shaft is horizontal, with an auxiliary peak, or " subcritical " at half the main critical speed.

Tests on the 5,000 lb. rotor are described which give general confirmation of these characteristics.

A Photoelastic Study of the Stresses in Wing Ribs. (T. J. Dolan and D. G. Richards, J. Aeron. Sci., Vol. 7, No. 8, June, 1940, pp. 340-6.) (80/30 U.S.A.)

To investigate the stresses in wing ribs by the photoelastic method of stress analysis, tests were made employing five small transparent bakelite models of various wing rib designs subjected to a loading condition similar to that occurring on a wing in the positive high angle of attack position. Photographs of the interference fringes, formed on the image of the model when stressed in polarised light, were interpreted in terms of stresses in the models. These data permitted the study of maximum stresses and all boundary stresses, prediction of the probable point and type of failure, and the study of relative weights of the various designs for the same thickness.

The Influence of Taper on the Efficiency of Wide Flanged Box Beams. (E. Reissner, J. Aeron. Sci., Vol. 7, No. 8, June, 1940, pp. 353-7.) (80/31 U.S.A.)

The problem of the efficiency of wide (shallow) box beams has been the object of many investigations. However, there seems to be no information concerning the influence of beam taper. In the present note the theory of plane stress is applied to the determination of the stresses in the cover sheet of a box beam of tapering width. Only a few cases are treated here; these demonstrate how other cases of " shear lag " in beams of tapering width may be studied in an analogous manner. The present calculations indicate that a taper in width reduces shear lag, *i.e.*, it increases the beam efficiency compared with the values for untapered beams of the same maximum width.

The Study of Elastic Structures by Means of the " Principle of Equivalent Loads." (L. Broglio, Atti di Guidonia, No. 10, 10/6/39.) (80/32 Italy.)

The usual method of stressing statically indeterminate structures depends on a knowledge of the elastic equation of the corresponding determinate problem

obtained by substituting analytical expressions for the reactions at the redundant connections.

The labour entailed in this calculation can be considerably reduced if the original redundant structure is split up into a number of simpler structures, each of which being still redundant. If several elements of the original structure are rigidly connected, it is generally simpler to introduce the displacement rather than the reactions at these points into the calculation as unknown variables.

The author next shows that the stress (or displacement) of any section of any redundant structure, however loaded, is given by the algebraic sum of :—

(1) The stress (or elastic displacement) corresponding to the condition of absolute rigidity of the connections of the element considered.
(2) The stress due to a " characteristic load " applied to the whole system.

The parameters defining the " characteristic load " can always be chosen so that it becomes an " equivalent load," *i.e.*, one which produces the same displacements of the connecting point as the original load.

The new method offers considerable advantages in simplicity and enables changes in stress corresponding to variation in load to be readily estimated, provided the stress distribution due to a particular load has been determined.

Calculation of the Elastic Curve of a Helical Compression Spring. (H. C. Keysor, Trans. A.S.M.E., Vol. 62, No. 4, May, 1940, pp. 319-26.) (80/33 U.S.A.)

Equations for the elastic curve of a helical compression spring are developed, without making the usual assumption of axial loading. The load is found to be eccentric, in general, being axial only under certain conditions. Elastic curves are given for both axial and eccentric loading. These curves are sinusoidal, showing that deflection along the bar is not linear, as is customarily assumed. A reversed deflection is found to occur in the closed end, back of the tip contact point, which increases the deflection of the spring as a whole, and shows that it is not correct to consider the entire closed end as inactive. An axial load is theoretically possible under certain conditions, but practically axial loading is difficult to obtain and cannot be counted on with any certainty.

Helix Warping in Helical Compression Springs. (D. H. Pletta and F. J. Maher, Trans. A.S.M.E., Vol. 62, No. 4, May, 1940, pp 327-9.) (80/34 U.S.A.)

When helical springs are compressed between parallel planes, the load is usually eccentric with the longitudinal axis and the helix, in its deflected position, is no longer truly helical but assumes a sinusoidal or warped shape. The magnitude of the eccentricity and of the warping is a function of the number of turns in the spring.

The research reported on here illustrates this warping for a heavy helical spring, whose length was varied for the series of tests, and it also compares the test results with the theoretical behaviour as outlined in the accompanying paper of H. C. Keysor (see Abstract 80/33). In general, the actual and theoretical behaviour were in excellent agreement, thus apparently substantiating the theory. An analysis of the data also emphasises the need of always assuming some eccentricity of load in practical design, to allow for the lack of perfect concentricity of the individual turns.

Approximate Methods for Stress Calculations of Rotating Discs. (H. Baer, Z.V.D.I., Vol. 84, No. 21, 25/5/40, pp. 359-301.) (80/35 Germany.)

The author refers to the importance of calculating the strength of turbine impellers, owing to the very high tip speeds (of the order of 400 m./s.) at which they rotate. Reference is made to various methods of determining the stresses

in rotating discs by dividing the disc into a number of rings or discs which as far as possible reproduce the profile of the rotating disc and calculating the stresses of the individual rings.

Two particular methods are compared, viz., the Keller-Salzmann method and the Moyes method.

In the former method the rotating disc is divided into only a small number of rings or discs by utilising cone-shaped discs, the outer width of one ring being equal to the inner width of the next succeeding ring, so that the radial and tangential stresses at the point of transition from the one ring to the other are the same for both rings. In one example by Salzmann the rotating disc is divided into only one flat ring and two cone-shaped rings. The calculation of the stresses is simple. The tangential stress 6_u at the hub or bore (as a rule the greatest stress) can be quickly calculated with sufficient accuracy.

In the latter (Moyes) method the rotating disc is divided into a large number of rings or discs, even in cases where according to the Keller-Salzmann method only one cone-shaped ring is used. This is due to the fact that Moyes employs for his calculations the method of small differences, which becomes the more exact, the smaller are the radial thicknesses of the rings.

In cases where exact calculations can easily be carried out (when the rotating disc is bounded by plane surfaces) the more exact Moyes' method can be employed. Both methods can be combined. For details of Moyes' method, see "Determination of Stresses in Rotating Discs under Elastic Conditions," Engineering, Vol. 147 (1939), pp. 241-43.

The Effect of Rest Periods on the Endurance and Fatigue Strength of Metals. (F. Bollenrath and H. Correlins, Z.V.D.I., Vol. 84, No. 18, 4/5/40, pp. 295-299.) (80/36 Germany.)

It is known that the type of load variation occurring in actual practice plays an important part in the endurance and fatigue strength of engineering materials. Laboratory tests should therefore imitate as closely as possible practical conditions. Of special interest is the resistance to oscillating loads well above the fatigue limit, provided such loads only occur at infrequent intervals during the design life. In this connection, the possible effect of rest periods (*i.e.*, periods of time during which the material is free from load) on its endurance become of importance. The author investigated a number of Al, Mg, Fe and Cu alloys, utilising a hydraulic pulsator operating at 1,000 stress cycles per minute (variable tension). During each cycle the stress varied between a fixed lower limit (usually 5-7 kg./mm.^{2}) and an upper limit, which was either maintained constant till the specimen failed (normal Wohler curve) or rest periods (varying from 6-18 hours) were interposed after a definite number of load cycles during the test.

The results show that for the materials examined, the two Wohler curves are in agreement within the limits of experimental error. The number of load cycles required to produce fracture with a stress cycle of a given amplitude is thus unaffected by rest periods during the test.

Bi-Metal Foils for Brazing Hard Alloy Tips on Tools. (Z.V.D.I., Vol. 84, No. 18, 4/5/40, pp. 310-311.) (80/37 Germany.)

The usual method of brazing hard alloy tips on to the body of the tool may lead to cavities existing between the tip and the tool shaft which may cause the tip becoming unstuck or even fracturing. This difficulty is overcome by making use of special copper-steel foil, consisting of small grooved steel plates covered with silver solder and embedded in a copper solder. This foil is placed in the cut out portion of the tool, the tip placed in position and the whole heated in a muffle furnace to the requisite temperature. Details of the subsequent treatment are given and it is stated that perfect adhesion can be ensured for tips of not more than 3-4 mm. thickness.

Commercial Ozone. (A. E. Williams, Engineer, Vol. 169, No. 4,406, 21/6/40, pp. 557-558.) (80/38 Great Britain.)

Ozone is produced commercially by subjecting dry air to a silent electric discharge. Modern ozone generators employ special porous dielectrics and wire gauze electrodes and require only moderate voltages (of the order of 5,000 at 25 cycles/sec.). About 300 gm. of ozone are produced per kilowatt hour at low concentrations suitable for ventilation, whilst at very high concentrations the yield is about 150 gm. per kw. hour. Representative types of commercial plants are described. The main use of the ozone is for sterilisation of water, one unit of electricity being generally sufficient to treat 5,000 gallons.

Recent Developments in the Use of Hydraulic Power. (H. C. Town, Proc. Inst. Mech. Engs., Vol. 143, No. 2, May, 1940, pp. 129-141.) (80/39 Great Britain.)

The utilisation of hydraulic power is considered in the following industries:—

1. Plastics and metal stamping.
2. Motor car.
3. Aircraft.
4. Machine tools.
5. Textile.

Until comparatively recently, power operation by hydraulic means had undergone practically no development since the early days of its inception. Modern impetus is largely due to the introduction of variable delivery pumps as self-contained units which are introduced into the circuit where required and take the place of the central pumping station in use formerly. These units are available with a normal maximum pressure of 1,000 lb. per sq. in., but in certain cases may go up to 5,000 lb. per sq. in.

For many years the crank or toggle press has had a monopoly in the drawing and stamping industries, but the modern high speed hydraulic press has now entered the metal stamping field and established production records which cannot be approached by other types. Hydraulic power has also been successfully employed for copying or duplicating dies for presswork. In the motor car industry the " fluid " drive possesses many advantages. The application of hydraulic drive to machine tools seems to have received special attention in Germany. In the case of shapers, for example, this method makes the cutting and return speeds independent of each other, whilst both the feed and speed are stepless. In the textile industry, the hydraulic drive facilitates synchronisation of a number of machines (cloth finishing) and provides the sensitive control needed for drawing frames and warp sizing. Finally, with the development of aircraft, an increasing need has arisen for reliable and efficient actuation of remote units and hydraulic actuation has received extensive application not only in the case of retractable undercarriages, shock absorbers, launching gear and propellers, but also in more delicate instruments such as automatic pilots.

Small Inertia Type Machine for Testing Brake Lining. (R. H. Taylor and W. L. Holt, Bur. Stan. J. Res., Vol. 24, No. 5, May, 1940, pp. 531-46.) (80/40 U.S.A.)

This paper describes a machine of the inertia type which has been developed and built for testing small samples of brake lining. The operation of the machine consists in bringing a fly-wheel up to a predetermined speed at equal intervals of time and stopping it by means of a brake mechanism which employs the lining under test. The machine is fully automatic in operation and was designed to permit the measurement of the coefficient of friction and wear of brake lining under a variety of test conditions simulating those encountered in service. The interval between stops, the speed from which stops are made, the pressure of

the lining on the drum, and the moment of inertia of the fly-wheel may all be varied within limits. The machine has been used to determine the coefficient of friction and rate of wear of a large number of brake linings.

Smooth drums will cause a lining to wear much less rapidly than rough ones and, in general, will give more nearly uniform results. Furthermore, the change in the rate of wear during a test is considerably greater with a rough drum.

Effect of Paint on the Sound Absorption of Acoustic Materials. (V. L. Chrisler, Bur. Stan. J. Res., Vol. 24, No. 5, May, 1940, pp. 547-53.) (80/41 U.S.A.)

A large number of the materials which are now sold as acoustic materials do depend to a considerable extent for their sound absorption on the porosity of the materials. A few of these materials have very large pores which are so interconnected that the sound absorption can be increased to a limited extent by partly closing the pore openings at the surfaces. Other materials have small openings which are not so well interconnected, with the result that the sound absorption is decreased as soon as any of the pore openings are closed. Owing to these differences, the effect of a coat of paint in changing the absorption due to porosity varies considerably for different types of material.

Sound may also be absorbed by setting the material into damped vibration as a diaphragm, the more the damping the greater being the absorption. Likewise, a soft material may absorb sound by inelastic yielding.

Where there is a damped vibration of a diaphragm, the maximum absorption occurs at a frequency equal to the natural frequency of the diaphragm and the absorption decreases at frequencies both above and below the natural frequency. When paint is applied, there is a slight increase in weight and in many cases an increase in stiffness. As a result of these changes, the frequency at which maximum absorption occurs will be changed; but in some cases the average absorption may remain about the same.

When the absorption occurs in a soft material because of an inelastic yield, this can be taken as a special case of a damped vibration of a diaphragm—that is, the natural frequency has approached zero. To-day it is seldom that a material of this type is found, but a few years ago a very common treatment was hair felt on which was glued a painted membrane. After a few coats of paint were applied, the pores were completely sealed. Under these conditions most of the absorption was due to an inelastic yield of the felt. In this case additional coats of paint increased the weight and stiffness of the surface membrane and, as a result, decreased the absorption of the material.

Mean Temperature Difference in Design. (R. A. Bowman, A. C. Mueller and W. N. Nagle, Trans. A.S.M.E., Vol. 62, No. 4, May, 1940, pp. 283-94.) (80/42 U.S.A.)

In heat transfer apparatus the rate of heat flow from the hot to the cold fluid is proportional to the temperature difference between the two. For design purposes, it is necessary to be able to determine the mean difference in temperature from the inlet and exit temperatures. Numerous investigators have contributed analyses of the temperature difference for exchangers with neither counter nor concurrent flow. This paper co-ordinates the results of previous studies on the same basis to give as complete a picture as possible of all the various arrangements of surface and flow. Shell-and-tube exchangers with any number of passes on shell side and tube side are covered, as are the crossflow exchangers with different pass arrangements and with mixed and unmixed flow. The special cases of trombone coolers, pot coolers, and batch processes, not previously published, are also treated in detail.

While it may be possible by using an exchanger other than a counter-current type to increase the over-all heat transfer coefficient more than the lowering of

the true mean temperature difference, there are, however, some types of exchangers for which certain temperature conditions cannot be met irrespective of the value of the heat transfer coefficient. No method of calculating the true mean temperature difference for the cross-flow case has been developed for cases where the flow is not either completely mixed or unmixed.

The Rectangular Metallic Hollow Conductor as a Transmitter of Electro-Magnetic Waves. (H. Riedel, H.F. Technik., Vol. 53, No. 4, April, 1940, pp. 122-9.) (80/43 Germany.)

The properties of hollow conductor waves in a conductor of rectangular cross-section are derived by simple methods. If an electric and a magnetic wave are combined, with suitable selection of the excitation values, two new wave forms are obtained, wherein the electric or magnetic field develops exclusively in the plane of the longitudinal section through the cable, and are thus given the definition of "longitudinal waves." Whereas in a circular cross-section the specific case of an H_0 wave exhibits a decrease in the damping with increasing frequency, the rectangular cross-section does not exhibit an analogous development, irrespective of the wave form.

Effect of Radio Interference Suppressors on Engine Performance. (Autom. Eng., Vol. 30, No. 398, June, 1940, pp. 167-73.) (80/44 Great Britain.)

Suppressors consist of a resistance of 10,000 to 15,000 atoms fitted in each high tension lead adjacent to the sparking plugs. The results of both road and laboratory tests indicate that no effect due to suppressors is obtained at moderate or high speeds, or under appreciable load. In addition, side valve engines appear, in general, to be insensitive to the effect of suppressors. Some overhead valve engines are, however, affected by suppressors at the lower speeds, the maximum loss of power observed being 9 per cent. The tests show that the effect due to suppressors is usually much smaller than this.

The adverse effect of suppressors on overhead valve engines at low speeds is due to insufficient turbulence, and this can be remedied by the fitting of a shrouded inlet valve. On the other hand, an engine previously insensitive might become affected if the sparking plugs are pocketed.

Factors, such as mixture strength, ignition advance, sparking plug gap, leaky plugs, and spark energy, only have an effect if the predisposing condition of insufficient turbulence is present, but, even then, the effect of these variables is small.

Analysis of the Effect of Scattering on Radio Transmission (with Discussion). (T. L. Eckersley, J. Inst. Elec. Engs., Vol. 86, No. 522, June, 1940, pp. 548-67.) (80/45 Great Britain.)

It has been known for a long time that signals from strong commercial stations can be received in the skip zone. Early investigations with a short wave Adcock direction-finder showed that the signals within the skip zone are in general characterised by absence of bearing. The present paper is a complete investigation into the causes of such effects. It was found that they are due to momentary irregularities and small clouds in the E region of the ionosphere. These irregularities produce scattered signals. The investigation, first carried out with the Adcock direction-finder, was later made more definite and accurate by using short impulses from high power stations. The later investigations entirely confirm the original deductions.

The effects of such scattering on long-distance transmission, direction-finding, etc., are discussed. The phenomenon is considered to be a major factor in practically all transmissions.

Developments in Meteorological Sounding by Radio Waves (with Discussion). (A. W. Friend, J. Aeron. Sci., Vol. 7, No. 8, June, 1940, pp. 347-52.) (80/46 U.S.A.)

A method has been developed for utilising a small radio transmitter and receiver for directly sounding the troposphere by means of radio wave pulse echoes. Comparisons of preliminary data obtained by this method with those from balloon radiosonde and aeroplane flights indicate close agreement between the different tests in the measurements of the altitudes and of temperature and specific humidity discontinuities.

Hyperfrequency Electric Waves and Their Practical Use. (L. Brillouin, J. Frank. Inst., Vol. 229, No. 6, June, 1940, pp. 709-736.) (80/47 France.)

Hyperfrequency waves are defined as being of the order of 1 cm. Very little is known of this region till we reach a wave length of about 1/100 cm. (extreme infra red). The production of continuous (undamped) hyperfrequency waves of sufficient intensity is thus of considerable interest to the physicist for bridging the gap between radio and optics (emission and absorption spectra, molecular structure, etc.).

Ultra short waves are also of interest to the radio engineer for television, signalling, obstacle detection and transmission along dielectric cables. The author deals with the last named problem at some length. A hollow conducting tube filled with a dielectric (air, water, etc.) acts as a filter for electro-magnetic waves, only frequencies above a certain limiting value being generally transmitted. Moreover, the speed transmission of the guided waves corresponds to the group velocity and may differ appreciably from the speed of free space transmission.

Interesting analogies from the domain of ultrasonics are given. According to the author "a new field of research is being opened here with very curious theoretical and technical problems and a prospect of important practical applications."

LIST OF SELECTED TRANSLATIONS.

NOTE.—Applications for the loan of copies of translations mentioned below should be addressed to the Secretary (R.T.P.), Ministry of Aircraft Production, Thames House, Millbank, S.W.1, and copies will be loaned as far as availability of stocks permits. Suggestions concerning new translations will be considered in relation to general interest and facilities available.

Lists of selected translations have appeared in this publication since September, 1938.

TRANSLATION NUMBER AND AUTHOR.	TITLE AND JOURNAL.
1037 Regnauld, P. ...	*Experiments on the Penetration of Projectiles.* (Mem. de l'Artillerié Franç., Vol. 17, Part 4, 1938, pp. 731-71.)
1030 Crocco, L.	*A Characteristic Transformation of the Equations of the Boundary Layer in Gases.* (Atti di Guidonia, No. 7, 10/5/39, XVII.)
1040 Hollmann, H. E. ...	*Mechanical and Ballistic Models of Various Electronic Devices, including the Klystron High Frequency Generator.* (H.F. Technik., Vol. 55, No. 3, March, 1940, pp. 73-86. Selected parts.)
1050 Eck, B.	*New Methods of Calculation for Radial Fans and Blowers.* (Schweizerische Bauzeitung, Vol. 113, No. 4, 28/1/39, pp. 39-43.)
1022 Wimmer, W. ...	*The Measurement of Stagnation Temperature.* (Ing. Arch., Vol. 11, No. 1, Feb., 1940, pp. 1-23.)
1052 Chiappulini, R. ...	*The Detrimental Effects of the Armament of the Bomber on the Aerodynamical and Structural Qualities of the Aircraft.* (Riv. Aeron., Vol. 15, No. 10, Oct., 1939, pp. 11-22.)
1053 Lieneweg, F. ...	*On the Occurrence and Prevention of Corrosion in Electrical Measuring Instruments.* (E.T.Z., Vol. 60, No. 21, 1939, pp. 621-3.)
1054 Küch, W.	*Effect of Pressing Conditions and Composition on the Properties of Laminated Synthetic Resin Pressed Plastics.* (Z.V.D.I., Vol. 83, No. 52, 30/12/39, pp. 1309-16.)
1055 Riedel, H.	*The Rectangular Metallic Hollow Conductor as a Transmitter of Electro-magnetic Waves.* (H.F. Technik., Vol. 53, No. 4, April, 1939, pp. 122-9.)
1056 Sheremeter, L. G. ...	*The Effect of Increased Finning of the Cylinders on the Cooling of Air-Cooled Engines.* (Aeron. Eng., U.S.S.R., Vol. 14, No. 2, Feb., 1940, pp. 34-51.)

TRANSLATION NUMBER AND AUTHOR.		TITLE AND JOURNAL.
1057	Goethert, B. ...	*Influence of Wing Load, Aspect Ratio, and Wing Load Distribution Along the Span, on Flight Performance.* (L.F.F., Vol. 16, No. 5, May, 1939, pp. 229-46.)
1041	Von Kármán, T. ...	*Theoretical Considerations on the Problem of the Helicopter.* (Z.F.M., Vol. 12, No. 24, 31/12/21, pp. 345-54.)
1043	Weinbaum, O. ...	*Results of Exploration for Timber in Para and Amazonas.* (Pamphlet published by Ministry of Agriculture, Brazil.)
1044	Föppl, O.	*What Factors Determine the Inception of Flow and the Resistance to Fracture of a Material?* (Mitt. des Wöhler-Instituts Braunschwig, No. 35, 1939.)
1046	Kosberg, S. A. ...	*The Problem of Regulating Multi-Plunger Pumps to Obtain Uniform Delivery.* (Aeron. Eng., U.S.S.R., Vol. 13, No. 4, April, 1939, pp. 33-51.)
1047	Morath, E. ... ... Mertz, H.	*Researches into the Most Favourable Conditions for Obtaining Glued Joints.* (Mitteilungen des Fachausschusses für Holz-fragen beim Verein deutscher Ingenieure und Deutschen Forstverein, No. 14, 1936.)

ABSTRACTS FROM THE SCIENTIFIC AND TECHNICAL PRESS.

Issued by the
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(Prepared by R.T.P.)

No. 81. August 1940.

Dive Bombing. (A. Lidomici, Rivista Aeronautica, Vol. 16, No. 2, Feb., 1940, pp. 207-228; No. 3, March, 1940, pp. 389-400; No. 4, April, 1940, pp. 25-34. In course of translation.) (81/1 Italy.)

The author divides his paper into three parts, dealing respectively with the trajectory of the bomb, the tactics of dive bombing and the ballistic effects of the bomb.

I. Bomb Trajectory.—The equation of motion is integrated by Picone's method, use being made of Siacci's tables for the resistance function whilst an exponential law for the density variations is assumed. The method is described in detail by means of a worked out example.

II. Tactics of Dive Bombing.—It is very easily shown that, other things being equal, both the scatter in range and azimuth is the smaller, the steeper the dive of the aircraft at release. Vertical dive bombing has the additional advantage of giving a higher impact speed and shorter time of fall. The author investigates the chances of hitting a target of given dimensions when dive bombing from various altitudes and concludes that the number of aircraft required for a hit is least if the attacks are carried out singly. Although the accuracy of each individual bomb is greater in the case of vertical than for horizontal attack, it must not be forgotten that in the latter case, the bombs can be released in salvos and thus fewer aircraft may be required.

III. Ballistic Effect.—In dive bombing the impact angle of the bomb is nearly vertical and this improves the penetration considerably above that possible with horizontal bombing. The impact speeds, on the other hand, do not differ very much in the two cases.

Conclusion.—The chief disadvantage of vertical dive bombing is that it requires special machines and super pilots. Attack in formation is, moreover, very difficult. For this reason the author considers that for the present, dive bombing will be carried out at moderate angles ($\sim 50°$).

Linoleum as a Fire-Resistant. (Engineer, Vol. 170, No. 4,410, 19/7/40, p. 49.) (81/2 Great Britain.)

A number of tests have recently been carried out with incendiary bombs set alight on plain wooden floors, on wooden floors treated with fireproof paint, and on wooden floors, plain or painted, covered with various thicknesses of linoleum. In the case of both the plain and the painted wooden floors a 1 kilo bomb, after burning for ten minutes, will burn a hole right through the flooring to an extent sufficient to allow it to fall on the floor below. A similar test applied to the same floors covered with linoleum of the 6.70 mm. grade showed that after ten minutes the surface of the linoleum was charred but that the wood below was

not burned through. Even after allowing the bomb to burn itself out—that is to say, after about thirty-five minutes—the wood underneath was charred on the surface, but not burned through. Further, the area of the fire did not increase as the bomb continued to burn, the spluttering magnesium failing to ignite the surrounding linoleum. With lesser thicknesses of linoleum the protection afforded was naturally decreased, but even with a covering of the 3.30 mm. grade, eight minutes elapsed before the wooden flooring started to crackle. The tests were carried out in the open air while a stiff breeze was blowing, that is to say, under conditions much more favourable to the spread of fire than prevail within a house.

The Present Trend in Design and Size of Military Aircraft (digest). (B. K. Yount, J.S.A.E., Vol. 47, No. 2, Aug., 1940, p. 25.) (81/3 U.S.A.)

There is a definite trend to greater gross weight for each type of military aeroplane, due mainly to requirements for increased performance, which have called for larger and heavier power plants. The over-all size of our standard types remains about the same, due to increasing compactness of design.

The trend to greater speeds continues, increases in speed being attained through aerodynamic refinement and increased power.

Present effort in aerodynamic refinement is to achieve very smooth surfaces and true contours, and to eliminate all gaps and air leakages.

Increased wing loadings and improved high-lift devices are inevitable. Assisted take-offs for certain types are a possibility.

There is promise of achieving laminar flow over a large portion of the wing, with consequent large reduction in wing drag. This line of development points to pusher propeller installations.

Compressibility shock is becoming an imminent problem. Different wing sections and different fuselage shapes are being evolved to avoid compressibility effect. This effect indicates that maximum speed will be attained near sea level.

There will be increased use of stainless steel, magnesium, and plastic materials.

Superchargers are undergoing intensive development. Fuel in quantity of better than 100 octane rating can be expected soon. The trend to drive propellers through extension shafting has brought forth new power plant problems.

Expanding U.S. Production. (B. Foster, Flight, Vol. 38, No. 1,650, 8.8.40, pp. 103-4.) (81/4 U.S.A.)

The U.S. aircraft industry is analysed from the aspect of its possible expansion to produce 3,000 aircraft per month for export, airframe factories being selected as the easiest standard of productive capacity. There are at present 30 airframe factories in the U.S.A., the three classes of personnel employed being in the ratio:—Production 74 per cent., office 16 per cent., engineering 10 per cent. Total employees at April, 1940, were 70,000 and total floor space available was approximately 10 million square feet. The factory personnel, which averaged 60,000 for 1939, produced 5,856 aeroplanes, or 488 per month. Thus the necessary expansion so far as personnel is concerned must be at least six-fold; possibly more since the bulk of the 3,715 commercial aircraft built in 1939 are described as "light 'plane class." T. P. Wright, of the Curtiss-Wright Corporation, estimates that floor space in airframe factories must be increased four times to bring present production up to 3,000 per month. The same figure applies to quantity and cost of plant. The same authority estimates that an aircraft production rate of 2,000 a month can be achieved in 2½ years, or by January, 1943; a rate of 3,000 a month by the spring of 1944, and a rate of 4,000 a month by July, 1945.

These calculations are based on the assumption that 3,000 per month is the rate at which Britain requires to buy aircraft from the U.S.A. and no allowance is made for U.S.A. requirements.

The Pressure of Water Waves Upon a Fixed Obstacle. (T. H. Havelock, Proc. Roy. Soc., Vol. 175, No. 963, 18/7/40, pp. 409-21.) (81/5 Great Britain.)

The diffraction of plane water waves by a stationary obstacle with vertical sides is examined, in particular the variation of amplitude along the sides and the average steady pressure due to the wave motion. Results similar to those in other diffraction problems are obtained for an infinite plane and for cylinders of circular or parabolic section, and approximations are made for sections of ship form. The examination was made in view of possible applications in the problem of a ship advancing through a train of waves, and the results are discussed in relation to the average additional resistance in such circumstances. It appears that the mean pressure obtained on diffraction theory from the second order terms can only account, in general, for a small proportion of the observed effect; the motions of the ship, and in particular its oscillations, are essential factors in the problem.

Operational Methods in the Theory of Aerofoils in Non-Uniform Motion. (W. R. Sears, J. Frank. Inst., Vol. 230, No. 1, July, 1940, pp. 95-111.) (81/6 U.S.A.)

In this paper Heaviside's operators are employed to obtain the following results:—

1. New integral expressions convenient for numerical calculation are obtained for the lift and circulation of a two-dimensional thin aerofoil following a sudden change of its angle of attack or velocity.

2. Approximate expressions are obtained for the initial and final behaviours of these functions.

3. The circulation function is shown to be identical with the function that expresses the lift of an aerofoil during and following its entrance into a sharp-edged vertical gust.

It appears that in problems concerning the non-uniform motion of two-dimensional thin aerofoils the mathematical analysis is most conveniently carried out by the use of Heaviside's operators.

Correcting Wing Drop on Landing. (B. Howard, American Aviation, Vol. 3, No. 24, 15/5/40, p. 10.) (81/7 U.S.A.)

When the wing starts down, to recover when seemingly nothing else will do any good, throw the control stick or wheel forward enough to pick up the tail of the aircraft to somewhere near level flight position. When this is done and the tail comes up, the angle of attack of the wings is changed to a lesser angle and thereby takes the lift off the wings and throws the weight of the plane over on to the wheels.

Quite evidently the wing that is thrown up by the gust has more lift than the one that is down, whereas a method such as opening the throttle will tend to give it more lift, thereby forcing the low wing further into the ground and giving the plane more forward speed which is generally not the best thing in this position. If opposite aileron is applied to recover the wing to normal level position, it will force the aileron into the ground, doing more damage to the wing or aileron and increase the chances of nosing up and over in a more serious crack-up.

According to the N.A.C.A., if aileron is used at this speed, which is below stalled speed, it tends to slacken the speed of the wing even more which would naturally tend to make this wing drag more. When the stick is thrown forward and the tail picked up to near level or level flight position, more rudder control is gained immediately. This is important, as frequently the plane will start a turn or ground loop and this additional rudder control is needed to stop this loop. If some throttle is needed to speed recovery it now can be applied without any danger of digging the wing harder or flying off the ground in a critical position.

The Next 35 Years in Aviation and Fuels. (D. Beecroft, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 33-37.) (81/8 U.S.A.)

During the past 35 years, the science and practice of aviation has made great strides and progress during the last ten years especially has been phenomenal. Most of this progress has been the result of subsidised research, outstanding results of which have been the solution of the engine cowling problem and the determination of the optimum engine/propeller combination and nacelle position on multi-engined aircraft (N.A.C.A.).

The development of the variable pitch propeller, on the other hand, is an example of what private enterprise can achieve. There is every indication that aircraft design has now become more or less standardised and that future development will consist in improvements of well known features (flaps, landing gear, superchargers, blind flying and automatic landing devices, etc.) rather than in the introduction of revolutionary principles.

The author considers that the most urgent need is a reduction in the cost of manufacture, most likely to be brought about by the substitution of welding for riveting. Better communication between airport and town centre will also require careful planning. The introduction of the high speed transport plane for goods only is considered likely as well as the development of second class passenger traffic at reduced speed.

Fuel development in the past has been almost entirely due to co-operative research. It is comforting to read that " an adequate supply of petrol of all grades is assured for the next 35 years, since proved reserves of crude in the ground are greater than ever known."

Experience in Integral Aircraft Fuel Tank Construction. (F. C. Albright, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 291-3.) (81/9 U.S.A.)

The experience of Vought-Sikorsky Aircraft in the development of its present type of integral fuel tank construction is related in this paper.

Tests made on one type of tape in a seal subjected to aviation petrol at pressure up to 100 lb. per sq. in. showed that the tape was not plastic enough to fill in small irregularities in the sheet or extrusions forming the joint. The tests did show, however, that rivets with a washer of this tape inserted under the head did not leak. The experience gained in this work led to the successful method whereby a uniform thickness of cement is applied to the tape instead of the tank surface. Tests showed that this cement-coated tape has the desirable feature of expanding a greater amount than any of the materials tested when in contact with the petrol.

Concluding, the author announces that spot welding has been used with success; that one spot welded tank has had three years of trouble-free service; and that this method shows cost savings on some tanks.

Passenger Comfort in Commercial Aviation. (W. W. Davies, J.S.A.E., Vol. 47, No. 2, Aug., 1940, pp. 342-8.) (81/10 U.S.A.)

This paper presents a general picture of all the factors that contribute either directly or indirectly to passenger comfort while en route in a regular commercial air liner. It also shows a comparison of the factors that determine the passenger's choice as to type or mode of transportation. Comparison is made of passenger comforts ten years ago and to-day. Of the twelve factors considered as contributing to passenger comfort, six of these are classed as being directly contributing, namely, space accommodations, interior design, noise prevention, heating and ventilating, lighting and catering. Five are classed as indirectly contributing, namely, oxygen equipment, lavatory facilities, sanitation and fumigation, aeroplane operation, and vibration. The air line engineer's problem with respect to personnel instruction is analysed.

Covered specifically are those problems which are of concern to the air line engineer, and the constant study, development, and continuous improvement

being made in equipment are brought out. The need for adequate contact with the manufacturers in order that they may gain from the operator's experience is stressed.

Some Data on the Static Longitudinal Stability and Control of Aeroplane (Design of Control Surface). (A. Martinor and E. Kolosov, Central Aero-Hydrodynamical Institute, Moscow, Rept. No. 278, 1936. Available as Ministry of Aircraft Production Translation T.M. No. 941.) (81/11 U.S.S.R.)

In the solution of a number of problems on the stability and controllability of aeroplanes, there arises the necessity for knowing the characteristics of the tail surfaces of the types in common use to-day. Of these characteristics, the most important are the effectiveness and hinge moments of the tail surfaces. As has been shown in the present paper, there exists the possibility of determining these characteristics by the formulas obtained with a degree of accuracy sufficient for the purposes of a preliminary computation.

The general method of computing the critical centre-of-gravity location of the aeroplane (forward and backward) is considerably simplified. This is particularly true with reference to the critical backward centre-of-gravity location for which the case of stick-free flight is the deciding one.

Of all three types of servo control considered (flap, cut-out, and outrigger), the most favourable from the point of view of application as balance tab is the cut-out type, since it is light and structurally simple to mount with the usual form of horizontal and vertical tail surfaces.

From the point of view of maximum " efficiency of balance " and minimum loss in effectiveness of the main control surface, it is necessary to give the servo tab a larger aspect ratio.

Servo controls are at the present time used essentially in the form of trimming tabs.

There is a range, however, where servo balance tabs are entirely feasible. This is true in the case of large sized aeroplanes where servo motors of the electric and pneumatic types, etc., are not used. As the size of the aeroplane is increased (up to a certain limit) the importance of servo balance tabs increases and with full-weight balance of the control surface, they present one of the most suitable and effective means of reducing the stick forces. In this connection, systematic investigations of servo balance tabs on aeroplanes should be undertaken, since there are practically no data available.

Criterion of Vertical Fin Area for Modern Aeroplane. (F. L. Thompson, S.A.E. National Aeronautic Meeting, Washington, 15/3/40. Original available in R.T.P.) (81/12 U.S.A.)

A deficiency in vertical fin area has been a relatively common occurrence in aeroplanes during the past few years and in many cases the fin area had to be increased after preliminary test flights. The difficulties experienced have been either connected with directional instability or the development of large pitching movements during side slip. In some cases the unstable movements have caused the fin to stall and disconcerting reversal of the rudder force has been experienced. This latter condition is given chief consideration by the author of the present paper. The tendency towards inadequate fin area is probably associated with refinement in fuselage shape and increase in wing loading of modern aircraft. Designs have approached in appearance an airship with stub-wings rather than a so-called " flying wing " type and fin area should be proportioned according to the size of the fuselage rather than in accordance with wing area. The author accordingly proposes the ratio $(S_f \times l)/D^2L$ as a criterion for satisfactory fin area, where

S_f = fin area.
l = length of tail.
D = maximum diameter of fuselage.
L = length of body.

From a comparison of flight tests on a number of machines, it appears that the above criterion should be of the order of at least 0.4 for satisfactory operation.

Altitude and the Aircraft Engine (Digest). (E. F. Pierce, J.S.A.E., Vol. 47, No. 1, July, 1940, p. 28.) (81/13 U.S.A.)

The aircraft engine manufacturer's 1 lb. per h.p. at sea level becomes 2 lb. per h.p. at 20,000 ft., unless the utmost in engineering skill and ingenuity is put into the problem of increasing altitude output.

Comparing the effects of various methods of supercharging upon the engine power output and specific fuel consumption, as operating altitudes are increased, either the two-stage supercharger or the exhaust turbo method of supercharging appear to be required. For high altitude operation, the exhaust turbo in conjunction with the two-stage supercharger seems to offer the maximum in horsepower output, but with considerable installation complication. For low altitude operation, the " single speed non-intercooled engine offers the maximum output with a minimum of installation complication."

The principal factor retarding development towards improved economy and higher specific output is the difficulty of obtaining precise and comprehensive data under actual flight conditions due to the lack of suitable flight test facilities. The capital expense necessary to provide one or more aeroplanes suitable for modern engines is very great, and the time element cannot be overcome at the present pace of the industry which is concentrating on development of new types of engines.

It appears that data obtained in flight with the torque meter provide excellent substantiation of the empirical formulas used for the determination of engine performance at altitude. Fuel consumption at altitude is related definitely to the power and speed values required for the aeroplane operation. For a given supercharger speed ratio, the minimum specific fuel consumption values are obtainable only at the lower altitudes, and curves of engine fuel requirements must be correlated suitably with the altitude power curves of the engine before such curves are of practical use.

Geared Engines for Light Aeroplanes. (C. H. Wiegman, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 301-4.) (81/16 U.S.A.)

The high speed geared engine with its slow turning propeller will open new fields for the light aeroplane due to the superior take-off and climb performance of the geared engine when compared with those of high speed direct drive engines of equal horse-power.

Among the problems that had to be solved in the development of geared engines of the four-cylinder two-bank, horizontally opposed type discussed was that of the high amplitudes of 4th and 2nd order crankshaft torsional vibration encountered in the operating range. Damping through the use of a Lanchester friction type damper, the size of which was as large as practical, reduced the 4th order resonance successfully, but increased the 2nd order amplitudes at comparable speeds in the operating range of the undamped engine. The author announces that extremely low amplitudes are obtained, however, through the use of the pendulum type or dynamic damper.

Altitude Performance of High Output Aircraft Engines (Digest). (R. N. Du Bois, J.S.A.E., Vol. 47, No. 1, July, 1940, p. 28.) (81/14 U.S.A.)

As the first step in the investigation of altitude performance, the power of the engine cylinder under all possible conditions of manifold pressure, manifold temperature, and exhaust pressure must be determined. Describing the single cylinder laboratory at his company's plant, the author states that it is possible to produce in this laboratory any desired exhaust suction; manifold pressures up to 150 in. hg.; inlet air temperature up to 400°F.; and to handle engine speeds up to 5,000 r.p.m.

Maintenance of power at altitude by means of the exhaust driven turbo compressor affords a most convenient way out for the engine manufacturer; the troubles, if any, are transferred to the builder of the turbo and of the aeroplane. The author considers " worthy of considerable attention " the use of a two-stage supercharger with an auxiliary engine to drive the first stage. This arrangement is especially applicable to large aeroplanes.

Other supercharger arrangements discussed are the single-stage geared compressor; two-speed drives; continuously variable drives; two-stage geared superchargers; and modified two-stage installations; such as two-speed both stages, by-passed first stage and the two-speed first stage.

The two-speed first stage method of using two stages is the most satisfactory yet considered since three steps of supercharging reduce the amount of throttling required and, therefore, improved the overall efficiency of the system.

Economic Aspect of Light Aeroplane Engines. (C. T. Doman, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 284-90.) (81/15 U.S.A.)

This paper discusses the parallel design and development work of two air-cooled engines with widely different applications, although the basic design of both engines is quite similar. Instead of following the usual aircraft practice in any detail, the author points out the advisability of using automotive practice and thus bringing about a simplicity in design which is impossible when following the normal aircraft practice.

The cylinder design of the two engines is discussed and points of similarity shown.

A description is given of an 80 h.p. 176 cu. in. aircraft engine, and the reason why the design for this particular engine was selected over five other types which were designed, are given.

It is pointed out that the use of large production automotive equipment such as starters and generators in light plane engines effects economies which can never be expected by using the more specialised apparatus which is available for aeroplane engines only.

The author claims that the recent increase in the sale of the light aeroplane results, to a large extent, from the efforts made by the engine builders to bring about production economies and thus decrease the cost of the power plant.

C.U.E. Co-operative Universal Engine for Aviation Engine Single Cylinder Research (Digest). (A. W. Pope, Jr., J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 52-3.) (81/17 U.S.A.)

The fact that 12 C.U. engines have been built and 10 more are under construction demonstrates the effectiveness of the co-operative method in stimulating and executing research.

Some years ago the S.A.E. Ignition Research Committee expressed the need for a standardised single cylinder engine which would " take actual full-scale aviation engine cylinders into the laboratory under accurately controlled operating conditions for aviation spark plug research." Such an engine was displayed at the S.A.E. Semi-Annual Meeting in 1937. Although this engine did meet the needs of the spark plug manufacturers, it did not fill the needs of the petroleum industry, which was interested primarily in lubricating oil and fuel tests.

A volunteer group, organised at the 1937 S.A.E. Semi-Annual Meeting first listed the features which such a design must include and then a small design sub-committee was formed to study and co-ordinate the requirements. Counting the original spark plug test engine, five complete designs were made before a combination was developed which appeared to meet all requirements in a satisfactory manner.

The single-cylinder crankcase design was laid out to provide for the Wright Cyclone air-cooled cylinder, $6\frac{1}{8} \times 6\frac{7}{8}$ in. bore and stroke.

A detailed description of the C.U.E. design and construction comprised the major part of the paper, covering such features as:—The balancing system; main roller bearings; smooth-walled crank chamber; lubrication; crankcase construction; temperature control; crankcase seal; accessory drives; crankshaft; connecting rod; speed; spark indicator; flywheel; reverse rotation; dynamometer coupling and fuel injection system.

Comparison of C.U.E. Engine Installations (Digest). (A. L. Beall, J.S.A.E., Vol 47, No. 1, July, 1940, p. 53.) (81/18 U.S.A.)

After discussing the divergence in installation details and accessories among the installations, bringing out items of special ingenuity or usefulness, the authors emphasised that some compromises are needed from each laboratory to make the units similar. Further compromise in installation detail or practice also is indicated to insure comparability with the multi-cylinder engine, noting that the data needed to make the compromises are available.

The primary object—to substitute the single-cylinder engine for a multi-cylinder engine test as a measure of the quality of an aircraft engine lubricating oil—has sufficient merit, the authors concluded, and, if fulfilled successfully, it will result in such economy as to warrant substantial effort in its completion. At the moment, however, no two of the co-operative universal engines as now set up are likely to provide comparative data, and none seems to be sufficiently closely related to multi-cylinder engine practice to insure comparability of results with the large engine.

An Analysis of the Charging Process in the Two-Stroke Engine (Digest). (C. F. Taylor, J.S.A.E., Vol. 47, No. 1, July, 1940, p. 54.) (81/19 U.S.A.)

The author emphasised the need for specific definitions and indices whereby the performance of two-stroke engines tested in different laboratories and by different personnel can easily be compared.

In the case of the charging process, it is important to know how much fresh charge is available in the cylinder for combustion; how much charge is delivered through the inlet ports; what charging pressure is required, and how much work is expended in charging.

To stimulate discussion on the subject, several indices applicable for evaluating the scavenging process in all types of two-stroke engines are suggested. A feature of the paper is the explanation of a new method for measuring scavenging efficiency developed at M.I.T., and the results obtained.

The ideal charging process, toward which engineers are working, would consist of " the admission of the fresh charge (which may be air or a mixture of fuel and air) through the inlet ports in such a way that it displaces the residual gases from the previous stroke without mixing or exchanging heat with them, or with the engine parts."

Wear Resistant Coatings (Digest). (J. E. Jackson, J.S.A.E., Vol. 47, No. 1, July, 1940, p. 55.) (81/20 U.S.A.)

The problem of scratching or scuffing of Diesel engine cylinder liners during the run-in of the engine may be largely eliminated through a caustic sulphur treatment for the honed liners before assembly.

Through the various properties of the caustic sulphur treatment, the run-in is given ample opportunity to produce the most favourable wear resistant coating which the liner material is capable of forming. As a small amount of surface is worn away, a new layer of the wear-resisting coating will be formed in the next reciprocations of the piston.

Newly assembled Diesel engines require a run-in before being placed in service, to bring about a " mating " of all bearings. The difficulty of lubricating the smoothed honed liner bore during the period of structural change makes " scratching " or " scuffing " imminent during run-in.

Surface treatment is no cure-all and its use does not permit less rigid specifications of lubricating oil and liner materials.

Piston Ring and Cylinder Wear (Digest). (E. W. Templin, J.S.A.E., Vol. 47, No. 1, July, 1940, p. 59.) (81/21 U.S.A.)

Tests show that specially coated rings are not standing up as well as older types. This might be due, in some respects, to the fact that the rings themselves were not wholly responsible for their own wear. Rings are usually changed due to cylinder wear, and corrosion is, in a great many cases, the destructive factor.

To combat corrosion of the cylinder, the author's report of his own tests using " nitrided and otherwise heat-treated cylinder sleeves and chrome plated cylinders " suggested one type of solution.

Other proposed methods for extending piston ring and cylinder life include a system of cooling which carries the water jacket temperature to a consistent figure of 200°F., and a renewable type of crankcase oil filter.

Directing his talk to vehicle designers, the author urged that effort should be applied toward maintaining crankcase oil and jacket water at suitable levels of temperature to improved ring and cylinder wall life. Temperature control seems to be the most tangible factor for the designer to consider.

Coupled Oscillations of Aircraft Engine Propeller Systems. (M. A. Biot, J. Aeron. Sci., Vol. 7, No. 9, July, 1940, pp. 376-82.) (81/22 U.S.A.)

The coupled oscillations of a flexible propeller and an aircraft engine with arbitrary number of cranks is investigated. In the first part of this paper a practical method is developed to determine the complete dynamical characteristics of a rotating vibrating propeller of arbitrary shape, and the legitimacy of the approximations is checked with a numerical example. In the second part the first nine torsional frequencies of a V-12 engine, with a flexible propeller are calculated and compared to the frequencies of the free-wheeling propeller and those obtained by considering the propeller as rigid. The simultaneous influence of the engine speed on all nine frequencies and the general procedure to compute the complete critical speed spectrum are also indicated.

Dynafocal Suspension for Radial Aircraft Engines (Digest). (T. L. Yates, J.S.A.E., Vol. 47, No. 2, Aug., 1940, p. 30.) (81/23 U.S.A.)

Dynafocal suspension is described as a directional spring mounting system which accomplishes a true centre-of-gravity support for an overhung mass, and provides sufficient flexibility for the absorption of both angular and translational vibratory disturbing forces, without undue loss of stability for the supported assembly.

The name " Dynafocal " represents the term under which this system of engine mounting is being marketed. It is a combination of the original name, " Dynamic Suspension," and perhaps a more descriptive term, " Focalised Support." Credit for the conception of the focalised suspension should be given to the Massachusetts Institute of Technology, and practical development of the link method of application is credited to the Wright Aeronautical Corp.

This paper reviews the principles underlying the design and describes the Dynafocal suspensions now in use with the idea of showing the practical benefits which can be provided through the application of these principles.

New Engine Developments (Digest). (M. M. Roensch, J.S.A.E., Vol. 47, No. 2, Aug, 1940, p. 27.) (81/24 U.S.A.)

When, as often occurs, engines are not run in carefully, scuffing occurs. This scuffing may heal up with further running but, in severe cases, the rings may have to be replaced to restore control.

This scuffing may be eliminated or alleviated by the use of piston ring coatings. The major part of this paper is comprised of a discussion of different coatings used on the piston rings of three manufacturers, each of which has a different idea of a proper coating. These coatings—tin coating, iron-manganese-phosphate coating, and iron oxide coating—are applied by different methods, and both the method and chemical composition of each coating are explained.

Tin coating consists of an electrolytic deposition of tin on the surface of the piston ring. Iron-manganese-phosphate coating consists of an iron phosphate with a high percentage of manganese phosphate. This coating is softer than grey cast iron and sufficiently porous to adsorb an appreciable amount of oil. The treatment necessary to supply iron oxide coating consists of oxidising the machined surfaces of the iron to a predetermined depth in an enclosed chamber heated to a temperature of approximately 1,000°F. in the presence of a suitable gaseous oxidising agent.

Test results are reported showing that treated piston rings wear only half as much as untreated rings, and the difficulty of comparing results from one engine to another are stressed.

Modern Aircraft Valves. (A. T. Colwell, Intava World, Vol. 2, No. 6, July, 1940, pp. 138-43.) (81/25 U.S.A.)

The modern aircraft engine valve is meeting every requirement imposed upon it to-day (r.p.m. $>$ 3,000, B.M.E.P. $>$ 200 lb. per sq. in.). Many American valves are operating for periods of over 5,000 hrs. This successful operation is due to three major and several minor developments which are described by the author. The greatest single step is undoubtedly the adoption of sodium cooling. Next comes advances in forging technique making possible the one piece hollow head valve and lastly general improvement in cylinder head finning and port design. As a result of these major developments, the maximum exhaust valve temperature (near the seat) now seldom exceeds 600°C. whilst the maximum inlet valve temperature is only of the order of 350°C. Minor improvements listed by the author include: Austenitic steel for exhaust valves, stellite faced seats and silchrome seat inserts. The pressure lubrication of the rocker arm has greatly reduced stem and guide wear and improved cooling. Typical valves constructed by Pratt and Whitney, Wright, Allison, Hispano-Suiza, Gnome Rhone, Rolls-Royce, Bristols and Fiat are described. Some reference is also made to German valves (Bramo, Daimler-Benz and B.M.W.). It appears that the general trend is towards hollow head exhaust valves with larger cavities (sodium near seat). Valve stems are also increasing in diameter, as this increases the cooling and simplifies manufacture.

It was feared that progressive intergranular corrosion might limit the life of austenitic valve steel. The sodium cooling is, however, now so efficient that no sign of any corrosion is found even after several thousand hours' service.

Jumo 205 Diesel Extension Shaft on the Dornier Do. 18 Flying Boat. (Mech. Eng., Vol. 62, No. 8, Aug., 1940, pp. 615.) (81/26 Germany.)

The Junkers shaft has internal vibration dampers. It is nearly 6.5 ft. long and weighs 161 lb., including the propeller bearing, and is used to transmit the torque from a Jumo 205 Diesel engine to a pusher propeller. Each additional foot of length between the propeller and engine entails an extra weight of only 11.5 lb. The shaft extension does not require attention or servicing in flight, so that no extra burden is placed on the crew.

The straight line propeller shaft extension also enables the torques of a number of engines to be combined in a common gearbox and passed to a single propeller. Of course, such arrangements require the fitting of clutches which can be actuated at will while the power plant is in operation, since provision must be made for starting, warming up, and stopping (in case of trouble) each engine separately with the propeller at a standstill. A free-wheeling device is also necessary for

each engine, so that a defective one may be disengaged from the rest without affecting the proper performance of the power unit.

A 15 lb. Hydraulic Starter for Light Aeroplane Engines. (Mech. Eng., Vol. 62, No. 8, Aug., 1940, p. 616.) (81/27 U.S.A.)

The starter, in three sections, generates hydraulic power up to 700 psi in the pressure chamber. To start an engine with it, the pilot spins a small crank in the plane's cockpit. This forces fluid into an injector, then into a hydraulic cell where the pressure has been preloaded to from 150 to 190 psi. The force built up from the outside raises the pressure to a maximum of between 600 and 700 psi. This potential energy remains in the cell until the pilot, releasing a trip button on the instrument panel, allows the power he has created to act upon the starting mechanism.

The Combustion of Aromatic and Alicyclic Hydrocarbons V. The Products of Combustion of Benzene and its Monoalkyl Derivatives. (J. H. Burgoyne, Proc. Roy. Soc., Vol. 175, No. 963, 18/7/40, pp. 539-63.) (81/28 Great Britain.)

The progressive formation of products in the combustion of benzene and its monoalkyl derivatives has been studied by analytical methods, and the characteristic features of the isothermal reactions at various temperatures have been established.

A cool flame reaction of n-propylbenzene has also been investigated, and by comparison with corresponding isothermal combustions, it is concluded that the propagation of cool flames is conditioned by the accumulation of a phenylalkyl hydroperoxide.

The results are interpreted in the light of the theory of the two-stage process, and a schematic mechanism for the main combustion reaction is outlined. This comprises degradation of the side chain (if present) and rupture of the benzene nucleus, followed by rapid degradation of the higher aliphatic aldehyde thus formed, yielding finally formaldehyde and the ultimate combustion products CO_2, CO and H_2O.

Problem of Valve-Head and Valve-Stem Deposits (Digest). (A. T. Colwell, J.S.A.E., Vol. 47, No. 1, July, 1940, p. 52.) (81/29 U.S.A.)

Deposits on valve stems to-day are causing about 50 per cent. of the valve trouble in the automotive field, and slightly more than 50 per cent. in the aircraft field. Aircraft valve trouble is, however, proportionately far less than valve trouble in the automotive field. Although much work has been done on varnish and lacquer deposits, most of it has applied to pistons and rings, with valves receiving only passing attention.

The real cause of the deposit built-up is apparently traceable to fuel and oil since the deposits occur heavily in Diesel motors, particularly when low grade fuel is used, and because engines operating on butane are reported to be practically free from such deposits. Furthermore, the diversity of opinion expressed in a survey made to collect data and of steps taken to improve this built-up condition, indicate again that motors have individual characteristics and that no standard procedure works for all cases.

Valve deposits can be divided into six classifications; those on the valve head; the hard, flint-like deposit from operation; varnish on the stem; deposits under the head and on the stem at the valve head end of the guide formed by shuttle driving; deposits on intake valves; and deposits on valve seats.

It has been definitely proved that oils with good oxidation resistance at high temperatures cause the least trouble. The design problem, therefore, is to attempt to get a valve stem temperature at the top of the guide which will not cause oil decomposition; or to meter the oil so that the deposit formed is not thick enough to cause trouble between overhauls; or to remove the deposit in some way as it is formed.

Full-Scale Engine C.F.R. Progress Report on Diesel Fuel (Digest). (C. G. A. Rosen, J.S.A.E., Vol. 47, No. 1, July, 1940, p. 54.) (81/30 U.S.A.)

Work is progressing on the influence of cetane number, volatility, viscosity, and gravity of Diesel fuels as they affect cold starting, smoothness, low temperature starting, smoke, power output, fuel consumption, smell, and engine deposits. Four reference fuels have been established and are being used in these studies.

To date, reports have been received on engine testing conducted in nine different laboratories. In evaluating these data as submitted, the preliminary results indicated that, when low temperature combustion chamber envelopes are approached, high cetane helps idling, light load, and starting characteristics; smoke is the most pertinent characteristic influenced by volatility decreasing as the volatility increases; high volatility plus high cetane eliminates stink; and low gravity fuels give best horse-power output at lowest fuel consumption.

Among observations on tests conducted by individual laboratories, using different types of engines, were the reports that high cetane fuel gave the most hours before ring sticking; that lowest engine deposits came from the fuel which has combined good cetane rating and high volatility; and that the rate of pressure rise correlates with the cetane number.

The Effectiveness of the Burning in Non-Knocking Engine Explosions (Digest). (L. Withrow and W. Cornelius, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 60-1.) (81/31 U.S.A.)

Combustion was found to be approximately 81 per cent. effective in five different explosions which were recorded by means of high speed motion pictures and pressure cards while running the engine on iso-octane and benzene. The term "81 per cent. effective," means that, according to modern thermodynamic data, only 81 per cent. of the liberated heat energy is accounted for by the pressures observed during combustion; in other words, 19 per cent. of the liberated heat energy is apparently lost from the working fluid.

Flame picture and pressure data, together with the Hottel thermodynamic charts, make possible a comparison of the actual rate of inflammation of the charge with the rate of combustion required by the thermodynamic analysis for developing the observed pressures. These two rates of combustion are approximately equal during the inflammation of the first 10 per cent. of the weight of the charge and during the inflammation of the last 50 per cent. They differ markedly when the actual rate of inflammation is a maximum, and this value is attained in the present engine when from 25 to 40 per cent. of the weight of charge is burned.

As the actual rate of inflammation of the charge reaches and passes through its maximum value, most of the 19 per cent. of the liberated heat energy that is not accounted for at the end of the burning period disappears from the working fluid.

The authors concluded that the data presented indicate that it may be possible to increase the effectiveness of the combustion process in an engine operating under non-knocking conditions.

(It should, however, be pointed out that the experimental engine operated at a relatively low piston speed of 600 f.p.m. and the relative heat loss would be reduced at higher speeds.)

The Use of Small Single-Cylinder Engines for the Evaluation of Motor Oils (Digest). (A. O. Willey and C. F. Prutton, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 61-2.) (81/32 U.S.A.)

Small scale single-cylinder engines ($2\frac{5}{8}$ in. × $2\frac{1}{2}$ in. developing $2\frac{1}{2}$ h.p. at 1,800 r.p.m.) can be used advantageously for preliminary investigations of the service properties of oils when closely controlled testing procedures are used and when the tests are properly tied in with full-scale block tests and field experience.

The accurately controlled conditions are subjected to arbitrarily selected factors chosen to simulate and accentuate the specific type of service conditions under investigation.

The authors claim that the older basic items of specifications are inadequate for evaluating motor oils in terms of present-day refining methods and engine requirements, and describe how the small scale engines are used to evaluate such properties as detergency, ring sticking, varnish formation, and corrosive tendencies. Simplified laboratory tests for oxidation, corrosion, and other service properties of oils, do not correlate sufficiently well with service results to make them dependable as a means for predicting lubricating characteristics in an engine.

It is interesting to note that comparative tests with leaded and non-leaded fuels showed no measurable difference in the oil characteristics.

Severe Duty Engine Conditions as Related to Oil and Fuel (Digest). C. M. Larson, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 62-3.) (81/33 U.S.A.)

Although over 200 patents were issued for addition agents for oils and fuels in 1939, the final Utopian addition agent for present day needs for clean engines is still on the proving ground in truck, bus, and tractor operators' equipment.

The general feeling is that, regardless of any changes in engine design that might momentarily simplify lubrication problems, the output of engines will be increased to the limits set by the lubricants. For this reason, it is desired to develop better oils so that performance can be increased, yet to limit the types of oil necessary to a minimum.

Severe conditions generally are measured in terms of high power output. Such operations have brought about high piston ring groove and valve guide temperatures which greatly increase ring and valve sticking tendencies.

In the case of some high speed passenger car engines and some overloaded truck and bus engines, ring sticking is not a problem, but high crankcase oil temperatures cause excessive oxidation resulting in varnish on piston skirts and overhead valve mechanism. Time between crankcase drains, alloy type bearings, and blow-by contamination all relate to the severity of engine conditions.

The stability of motor oils is particularly difficult to evaluate, since the ageing condition prevailing in the engine is subject to constant change and differs from one engine to another.

The only reliable criterion of the performance of a lubricating oil is its influence on engine condition and can only be obtained by inspection of the disassembled engine.

Utilisation of Butane in Heavy Duty Automotive Equipment. (C. L. Parkhill, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 76-7.) (81/34 U.S.A.)

Summary of the advantages of butane:—

1. Butane operation results in substantially the same mileage and, in some cases, better mileage than that obtained from petrol. It will deliver less mileage than Diesel fuel, but compensates for this with other economic advantages.

2. It will deliver the same horse-power with lower engine weight than the Diesel.

3. Butane sells locally (Los Angeles) at 10 c. per gal.; the same price as Diesel fuel and 50 per cent. less than the contract price of even second structure gasoline.

4. With butane there is a total absence of trailing exhaust smoke, and obnoxious, nauseating exhaust odours.

5. Oil drain periods are extended, when butane is used, to 7,500, 10,000 and even 15,000 miles.

6. The capital investment in an Otto cycle engine adapted to butane operation is far less than the capital invested in a Diesel engine of similar horse-power.

7. The butane engine will amortise its cost more rapidly than the Diesel engine.

8. Engine maintenance costs are greatly reduced.

Design Factors Controlling the Dynamic Performance of Instruments (with Discussion). (C. S. Draper and G. P. Bentley, Trans. A.S.M.E., Vol. 62, No. 5, July, 1940, pp. 421-32.) (81/35 U.S.A.)

This paper presents a generalised treatment of instruments which have a single movable index, controlled by the magnitude of a single actuating quantity. Such an instrument acts as a system with one degree of freedom and is studied by the well-known methods developed for such systems. Instruments which include servo-mechanisms cannot be treated as systems with one degree of freedom and are therefore excluded from consideration. From the standpoint of static indications, it is shown that the essential properties of an instrument can be specified in terms of range, scale sensitivity, calibration error, environmental error, and uncertainty. The definition and use of each of these quantities is discussed.

It is shown that the response of an instrument to rapid changes in the actuating quantity can be calculated if two parameters called instrument characteristics are known. One of these parameters has the dimension of time and is called the characteristic time. The second parameter is non-dimensional and is called the damping ratio. Non-dimensional curves, showing instrument responses to three typical variations in the actuating quantity, are plotted for a series of values of the damping ratio. These curves are used in an illustrative example to show how the values of the instrument characteristics, required to keep dynamic errors below a given limit, can be determined in a practical case.

An Optical Smoothness Meter for Evaluating the Surface Finish of Metals. (J. Guild, J. Sci. Inst., Vol. 17, No. 7, July, 1940, pp. 178-82.) (81/36 Great Britain.)

A beam of light incident on a reflecting surface is reflected in a manner depending on the fine scale character of the surface. If this is perfectly smooth, all the light is reflected in a direction determined by the familiar law of specular reflexion by a mirror, whereas, if it is perfectly rough—a completely matt surface —the light is diffusely scattered in all directions, there being no special concentration in the direction of specular reflexion. For surfaces of intermediate character the reflected light is still diffused in all directions, but is most strongly concentrated in and near the direction of specular reflexion. The fraction of the total reflected light which is comprised within a small cone whose axis is in this direction provides a measurable property which increases with the smoothness of the surface. The present paper describes an instrument which was developed to utilise this property for testing the quality of finish of flat or approximately flat metal surfaces. A beam of light is concentrated on a small area of the surface to be tested. All the reflected light is collected inside a small integrating sphere whose internal illumination is indicated by a photo-cell of the rectifier type connected to a galvanometer. A shutter is fitted within the sphere which enables the specularly reflected light to be distinguished from the diffusely scattered light, and the ratio of the specular light to the total reflected in all directions, termed the S/T ratio for the surface, can be determined. It is shown that this ratio affords a very sensitive means of comparing surfaces for smoothness, and a table of typical results is given to show where some familiar types of surface finish come on the S/T scale.

A Speed Registering Stroboscope for Gyroscopes. (L. O. Cook, J. Sci. Inst., Vol. 17, No. 7, July, 1940, pp. 186-7.) (81/37 Great Britain.)

The paper describes a speed registering stroboscope of compact design, which is easily manipulated and accurate, with the advantage of self illumination, a lamp being automatically switched on when the instrument is held in a vertical position for observation. The instrument is set in motion by a lever driving a rachet wheel, coupled to an inverted train of gears. The stroboscope disc, which revolves very freely, is mounted in miniature ball bearings, and coupled direct

to the tachometer. The total weight including battery (which is housed in the handle) is 2 lbs.

Proposed Air Cleaner Test Code. (W. H. Worthington, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 294-9.) (81/38 U.S.A.)

Summarising the work of the Air Cleaner Test Code Sub-division, the Air Cleaner Test Procedure is presented in its revised "code" form as a laboratory method of test procedure. Included is a discussion of the properties of dust prepared by the usual screening methods, an outline of the accepted methods of particle size determination, and suggestions as to how dust of a definite particle size may be prepared.

An Instrument for the Continuous Measurement of Piston Temperature (Digest). (A. F. Underwood and A. A. Catlin, J.S.A.E., Vol. 47, No. 1, July, 1940, p. 63.) (81/39 U.S.A.)

The problem of developing an instrument for the continuous measurement of piston temperatures by the thermocouple method can be divided into three parts:—

1. The measuring instrument or instruments necessary.
2. The installation of the thermocouples in the piston.
3. The necessary electrical circuit connecting the two.

After reviewing the principle of operation of the potentiometer method of reading temperatures, the standard light beam galvanometer selected for use with the intermittent contacts is described. The sensitivity of the galvanometer is controlled by means of a variable ballast resistor connected across its terminals. A multiple switch makes possible the continuous measurement of one temperature or the intermittent measurement of several temperatures. The thermocouple circuit is closed at the bottom of each stroke and, with the galvanometer as an indicator, it is possible to balance the voltages and read the temperatures as in an ordinary instrument. Silver contacts are used.

Test data obtained with the instrument described by the authors include temperature gradients of both aluminium and cast iron pistons; the effect of load variation on piston temperatures; and the effect of spark advance on piston temperature.

A test car installation has shown that measurements can be made continuously on the road, the instrument requiring neither attention nor adjustments.

The Cinema Integraph. (H. L. Hazen and G. S. Brown, J. Frank. Inst., Vol. 230, No. 1, July, 1940, pp. 19-44.) (81/40 U.S.A.)

The machine is used to expedite the work of evaluating an integral of the form

$$F(y) = \int_a^{b \text{ or } x} f(y \pm x)\, g(x)\, dx$$

where $g(x)$ and the kernel $f(y \pm x)$ are known functions and y represents a variable parameter.

To perform the multiplication and integration process, the cinema integraph uses light from an incandescent source and an arrangement of masks. The light is measured by photo tubes in a manner similar to that used in an earlier machine. Motion picture film is used for the masks which transfer the functions $g(x)$ and $f(x)$ into the machine instead of the cardboard masks used in the earlier machine. From this use of motion picture film comes the name "Cinema Integraph." An important feature of the procedure is that analytic expressions for the functions are not required; the only requirements being that it be possible to plot them on a two-dimensional graph with sufficient accuracy, that each plot be single valued, and that any discontinuities be finite in number.

The time required to evaluate a parametric product integral using the new machine is not very great. Briefly, it is necessary first, to prepare the function films from the graphs of the functions using an auxiliary apparatus provided; second, to locate these films in the machine; and third, to make a few adjustments to calibrate the machine for the particular problem and to interconnect certain mechanisms according to the form of solution desired. From then on the operation is almost entirely automatic and the complete solution is obtained within a few minutes and is usually accurate to within approximately one per cent. of full scale.

An Instrument for Measuring Low Frequency Accelerations in Flight. (C. S. Draper, W. Wrigley, J. Aeron. Sci., Vol. 7, No. 9, July, 1940, pp. 388-401.) (81/41 U.S.A.)

Instruments for measuring the vibratory motions and strains which are directly associated with power plant operation in aircraft have been in service use for some time but equipment for studying the low frequency, high amplitude motions of wings and control surfaces has not been generally available. The measurement of such motions introduces certain problems of instrument design which are discussed in the present paper. An instrument which offers a practical solution of these problems is described and the results of performance tests are discussed.

A seismographic system consisting of a mass connected to the vibrating member by means of an elastic coupling and a damper is an essential part of an instrument for measuring vibration in aircraft. The performance characteristics of such systems are discussed with the aid of non-dimensional curves. By means of these curves the frequency ranges for satisfactory operation of instruments for measuring vibratory displacements, velocities, and accelerations can be quantitatively determined for various degrees of damping. It is shown that an accelerometer is the most suitable type of equipment for measuring low frequency, high amplitude vibrations.

The experimental accelerometer developed during the work reported in the present paper uses an oil damped seismographic system with an effective natural frequency of about fifty cycles per second. A variable reluctance system changes the inductance of two coils used as arms of an inductance bridge and thus controls the bridge output. The bridge is supplied from a 600-cycle, governor-controlled, motor generator set and feeds into a vacuum tube amplifier which in turn operates an oscillograph. The accelerometer operates with substantially constant sensitivity from zero frequency up to some high-frequency limit which depends upon the damping medium and may be as high as thirty cycles per second under proper conditions. A table is given which summarises the effect of oil temperature and viscosity on the operating range.

M.G.H. Performance Meter (Digest). (E. F. Harrison, J.S.A.E., Vol. 47, No. 2, Aug., 1940, p. 26.) (81/42 U.S.A.)

The instrument described in this paper indicates continuously on an electric meter the overall performance of a car in miles per gallon, just as the speedometer indicates continuously the speed of the car in miles per hour. Thus the effect of the variables can be observed at the time that they are influencing economy.

The major part of the paper describes an apparatus which produces a voltage which is a direct measurement of the speed in miles per hour and another piece of equipment which produces an electrical resistance which is a direct measurement of flow of gasoline to the engine in gallons per hour. These two electrical values are combined in such a way that the meter scale can be calibrated to give a direct reading in miles per gallon.

Influence of Cyclic Stress on Corrosion Pitting of Steels in Fresh Water and Influence of Stress Corrosion on Fatigue Limit. (D. J. McAdam and G. W. Geil, Bur. Stan. J. Res., Vol. 24, No. 6, June, 1940, pp. 685-722.) (81/43 U.S.A.)

By examination of surfaces and longitudinal sections of specimens of steel after stress corrosion, information has been obtained about the influence of cyclic stress (during corrosion) on the form and size of corrosion pits. A discussion is given of the theoretical stress concentration due to corrosion pits, and of the influence of size on the effective stress concentration.

By comparison of typical views of corrosion pits with curves representing the decrease of the fatigue limit with corrosion time, the forms and sizes of corrosion pits are correlated with the resultant lowering of the fatigue limit.

The stress corrosion process is discussed in terms of the general theory of corrosion of metals. With increase in cyclic stress and cycle frequency, the corrosion process is shifted from a cathodically controlled process toward an anodically controlled process.

Fatigue of Helical Springs. (R. R. Tatnall, Engineering, Vol. 150, No. 3,887, 12/7/40, pp. 36-7.) (81/44 Great Britain.)

The fatigue properties of a helical spring can be established by a comparison of the endurance limit of the material used with the true stress cycle, as determined by design specifications, allowance for curvature and other stress concentrations, and vibration effects. It seems that a large majority of spring failures are accounted for in the true stress values, while there are some, of course, which result from metallurgical factors. Because many springs are designed for limited space, it is not possible to give the allowance for the factors as outlined, which would prevent a large number of spring failures. It is not intended to imply that all springs need to be analysed in the foregoing manner. Fatigue is not a factor in many spring applications, but in those troublesome and annoying cases which do occur quite frequently, this outline gives the method by which the trouble may at least be understood, if not eliminated.

New Type of German Canned Food Container (Ind. and Eng. Chem. (News Ed.), Vol. 18, No. 13, 10/7/40, p. 589.) (81/45 Germany.)

New type of can container for packing food products, dispensing altogether with the use of tin plate, has been developed in Germany, according to a report from the American Consulate General, Frankfort-on-Main. Instead of tin for coating the iron, the base sheet for making the new type of can is coated with a phosphate film, applied by the well-known Bonder phosphate rustproofing process, controlled by the Metallgesellschaft A.G. of Frankfort-on-Main.

Instead of being soldered, the can is welded, enabling a further saving of 2 per cent. in can material. Special automatic machinery has been developed for achieving the welding in an efficient manner.

By means of the Bonder process, a thin, tight, and uniform phosphate film is placed upon the iron sheet in two or three minutes by immersion in a special phosphate bath. The entire production process requires 30 minutes.

Thermostatic Bimetals (with Discussion). (S. G. Eskin and J. R. Fritze, Trans. A.S.M.E., Vol. 62, No. 5, July, 1940, pp. 433-42.) (81/46 U.S.A.)

The use of thermostatic bimetals has increased rapidly during the last fifteen years. In this period, considerable study has been given the subject. The present paper reviews the available information dealing with the theory and practice in the application of bimetals. A lack of essential data concerning various pertinent properties of the material is indicated. Basic principles are thoroughly considered, as in the analysis of the mechanics by Professor Timoshenko and in the properties of nickel-iron alloys. However, a considerable

fund of useful data is also presented in the form of curves and tables which give the properties of representative bimetals.

The Significance of, and Suggested Limits for, the Stress in Pipe Lines Due to the Combined Effects of Pressure and Expansion (with Discussion). (D. B. Rossheim and A. R. C. Markl, Trans. A.S.M.E., Vol. 62, No. 5, July, 1940, pp. 443-60.) (81/47 U.S.A.)

This paper has been prepared as a vehicle for discussion of the following basic problems, on which agreement must be reached to establish a satisfactory working stress basis for pipe lines:—

1. Proper allowable stresses for combined pressure and expansion effects.
2. Influence of and limits for localised stresses under static and repeated loading.
3. Capacity of bolted joints to withstand expansion effects without leakage or damage to flanges, bolts, or gaskets.
4. Effect of pre-springing, self-springing, creep, and yielding on operating and off-stream stresses.

An attempt has been made to point out various aspects of each issue, rather than limit the presentation to the personal views of the authors.

Properties and Performance of Plastic Bearing Metals (with Discussion). (L. M. Tichvinsky, Trans. A.S.M.E., Vol. 62, No. 5, July, 1940, pp. 461-7.) (81/48 U.S.A.)

Bearings made of plastic materials can be used successfully not only for the case of perfect fluid lubrication but also for that of semi-fluid lubrication. Certain additions, such as graphite, will sometimes permit the application of these materials under conditions of dry friction.

By virtue of good physical properties these bearings find a wide application. Heavy duty plastic bearings are used in the steel mill industry. Lubricated and cooled with water, they carry heavy loads at pressures of several thousands pounds per square inch. As guide bearings their performance ranges from small, high speed spindles, to large ship propeller shafts. Oil, water, and grease-lubricated plastic bearings are used extensively in industrial, marine, and farm machinery.

There are many differences in the behaviour of plastic and metal bearing materials by virtue of which the performance is also different. This article intends to point out the most important physical properties, as well as some of the characteristic performances of plastic bearing materials.

Neoprene as a Spring Metal (with Discussion). (F. L. Yerzley, Trans. A.S.M.E., Vol. 62, No. 5, July, 1940, pp. 469-78.) (81/49 U.S.A.)

Analysis of spring applications reveals at least five outstanding reasons for the use of rubber springs. These are:—

1. To reduce noise. The function of rubber in this respect is to avoid transmission of audio-frequencies through metallic supports.

2. To impart flexibility. In addition to the technically more interesting applications, involving periodic vibrations which are subject to more or less precise mathematical treatment, there are numerous applications arising from the need for a mild cushioning effect.

3. To reduce production cost. The trend in modern machine production is toward lighter construction and higher speeds. In general, this means also that precision in manufacture must be increased, usually at an increase in the cost of machining operations. Rubber in compression will conform readily to irregular surfaces and can, in some cases, be employed to eliminate a machining operation as well as maintenance expense.

4. To reduce maintenance costs. Rubber springs frequently eliminate guides and other points of metal-to-metal contact, and thereby reduce maintenance costs.

5. To obtain definite damping action. When damping action is required with metallic springs, auxiliary frictional equipment is usually required. Leaf springs provide damping, but the extent of the damping action varies with the lubrication between the leaves and is not subject to practical control. The damping action of a rubber compound is definite and reasonably constant and is obtained without mechanical wear and without need of attention.

In this paper the mechanical properties of neoprene which are important for vibration isolation and damping are evaluated and compared with the analogous properties of rubber. Static and dynamic moduli and damping action are specifically treated.

Superfinishing. (Machinery, 4/7/40, pp. 435-7.) (81/50 Great Britain.)

A finishing grinding operation can rarely be accomplished without creating a layer of disturbed material, and may even cause surface annealing in hardened parts. This article describes a method of obtaining a finished surface by the application of fine grit abrasive stones to the rotating bearing surface under light spring pressure and under a flow of light lubricant. The equipment, the control of conditions and the necessary speeds are described, and details of experience with finished articles are given. Illustrated with one photograph. (Abstract supplied by Metropolitan Vickers Research Department.)

Creep Rates from Tests of Short Duration. (Kanter and Sticha, Trans. A.S. Met., June, 1940, pp. 257-76.) (81/51 U.S.A.)

This article is concerned with methods of determining creep rates from tests of short duration only. Attempts at correlating rate of creep and stress at constant temperature are reviewed, and a relationship between the logarithm of creep rate and the reciprocal of absolute temperature under constant stress is postulated. This relationship suggests a means of correlating small creep rates and large creep rates. The article describes the apparatus and the procedure for such an investigation, and gives an account of the results obtained. Illustrated with two photographs, four micrographs, three graphs and one diagram. (Abstract supplied by Metropolitan Vickers Research Department.)

Engineering Properties of Rubber in Compression (Digest). (R. W. Brown, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 22-25.) (81/52 U.S.A.)

The engineer can best visualise the performance of rubber when loaded by first considering it as a non-compressible fluid which flows from a region of higher pressure to any available region of lower pressure. Such flow is resisted by stresses within the rubber and by adhesion to the surfaces in contact with the mounting until equilibrium occurs. It is therefore necessary to consider the area and type of contact with the mounting to ensure accurate load-deformation measurements. Rates of load application and removal have been used generally in measuring load deformation which are much slower than occur on actual rubber parts in automotive service.

Presenting data concerning the compression characteristics of rubber to aid engineers in incorporating rubber into their products, the author defined seven properties of rubber—load deformation; stiffness; hardness; form factor; temperature factor; permanent set; and dynamic properties, including creep.

Discussing hardness, the generally used durometer method of measuring this property has " serious limitations and low accuracy " when applied to rubber, and the S.A.E. is co-operating with the A.S.T.M. to improve this condition.

Temperature curves are not ordinarily required in design computations for rubber parts in motor cars since the rubber functions in a commercially acceptable manner through the range of temperatures to which the rubber is subjected in a motor car.

The description of apparatus developed to measure the various properties of rubber includes dynamic performance-measuring and fatigue-testing equipment.

Load Carrying Capacity of Bearing Surfaces (Digest). (M. O. Teetor, J.S.A.E., Vol. 47, No. 1, July, 1940, pp. 55-6.) (81/53 U.S.A.)

The load-carrying capacity of a bearing surface is affected by surface finish, coefficient of friction, speed, thermal conductivity, lubrication, material, and depends markedly on temperature. Surface temperature is the temperature of the surface material, microscopic in depth and expanse. High surface temperature is the cause of surface failure, and bearing surfaces fail because the areas in contact reach the melting-point of the material.

Another factor stressed by the author is surface finish. It affects the load-carrying capacity because it determines the actual area and distribution of that area in contact. It appears that a bearing surface carrying a given load satisfactorily is dotted with high-pressure areas, microscopic in size and depth, that melt and cool almost instantaneously. The gradual oxidation that takes place constitutes the process of normal wear. It is only when the high temperature areas get too large and deep to cool instantaneously that failure occurs. Because of their ability to cool, rough surfaces have greater load-carrying capacity than smooth surfaces. Load-carrying capacity decreases as the contacting area increases, and can be increased by dividing the bearing surface into smaller areas. The capacity of such an interrupted surface can be increased further by filling the grooves or cavities separating the small bearing areas with a suitable material.

Production of Magnesium Alloy Aircraft Parts. (L. B. Grant, J.S.A.E., Vol. 47, No. 2, Aug., 1940, pp. 325-31.) (81/54 U.S.A.)

The author reviews the progress made and discusses the problems encountered by aircraft manufacturers in the production of aeroplane parts made from magnesium alloys. Although the procedures instrumental to the use of magnesium alloys are not unduly difficult or complicated, they should be well understood and rigidly followed so that the best results can be obtained from the use of magnesium.

The composition, mechanical properties and correlations with Government specifications are given in seven tables. Specific recommendations are made on design, pattern construction, chemical surface treatments, machining, assembly protection, and painting. Information also is given on welding, riveting and forming of sheet and extruded shapes.

A New Method of Testing and Grading Fine Abrasives (with Discussion). (E. L. Hemingway, J.S.A.E., Vol. 47, No. 2, Aug., 1940, pp. 332-41.) (81/55 U.S.A.)

When a stone of too great hardness is applied to a ground surface, its too-rigidly-held grits are not removed to dress and sharpen its face and the cutting action slows down much sooner than desired. When the stone used has too little bond strength, its action on the hill-peaks results in an extremely rapid removal of metal as the stone breaks down very fast.

After describing various preliminary tests, the author reveals that a Rockwell hardness tester with a $\frac{1}{8}$ in. steel ball and a 60 kg. load finally was selected for grading superfinishing stones. A curve is included that indicates the proper stone to use in superfinishing a given hardness of steel under standard conditions. Such graphs have been used for five months with satisfactory results, and the former difficulties have practically disappeared.

In conclusion, the author contends that every user of fine-grit bonded abrasive, no matter what their application may be, has at his disposal in this method an accurate means of predetermining their cutting characteristics.

The Dynamic Fatigue Life of Rubber (Digest). (S. M. Cadwell, R. A. Merrill, C. M. Sloman and F. L. Yost, J.S.A.E., Vol. 47, No. 2, Aug., 1940, p. 27.) (81/56 U.S.A.)

This paper reviews the results obtained in studies on the dynamic fatigue life of rubber. These results show the critical dependence of the fatigue life on the imposed oscillation conditions.

The dynamic fatigue life of rubber which is being vibrated linearly is discussed first, with a description of the apparatus and explanation of test methods. A dynamic fatigue life curve shows that the rubber under linear vibrations exhibits a minimum dynamic fatigue life when the minimum length of the vibrating member is equal to its free unstrained length.

Fatigue life curves obtained under constant-load conditions show a similarity to the fatigue life curves for constant-strain oscillation. Similarly, test data on the dynamic fatigue life of rubber vibrated in shear are entirely in accord with what would have been predicted from the linear fatigue data.

Cast Iron Cylinder Bores (Microstructure, Composition, Hardness and Wear) (Digest). (E. K. Smith, J.S.A.E., Vol. 47, No. 2, Aug., 1940, p. 28.) (81/57 U.S.A.)

In a summary of the effect of the various elements of cast iron on its microstructure when other variables are considered constant, it is brought out that silicon and carbon soften the iron; that manganese aids in controlling the effect of sulphur; that high phosphorus content tends to make the iron brittle, but hard phosphide inclusions retard wear; that nickel acts as a graphitizer, promoting machinability; that chromium forms stable carbons; and that molybdenum promotes strength.

It is concluded that cast irons with normal flake graphite give the best wear; those with large amounts of ferrite give poor wear; irons with ferrite-fine graphite structure give the worst wear; and irons with excessively coarse graphite give porous bores.

The paper concludes with a brief digest of current ideas on the causes and prevention of cylinder wear, including abrasion, corrosion and structure.

Creep Under Combined Tension and Torsion. (Tapsell and Johnson, Engineering, 26/7/40, pp. 61-3.) (81/58 Great Britain.)

The authors now publish the results of their first series of tests. All the creep strain-time curves are shown to have the same geometric form, so that the creep rates after 150 hours for all conditions of stress are comparable. It is shown that in the pure tension tests the axial creep rate is proportional to a power of the stress, and this suggests that a similar relation is true under various combined stress conditions. The experimental results as a whole are examined in the light of theoretical expressions derived by various authors in the past, and new expressions are formulated. The results provide evidence that after a definite time the creep rate in the direction of major principle stress is proportional to the difference of powers of the maximum shear stresses. The article is to be continued. Illustrated with seven graphs. (Abstract supplied by Metropolitan Vickers Research Department.)

Optical Plastic Materials. (Mech. Eng., Vol. 62, No. 8, Aug., 1940, p. 613.) (81/59 U.S.A.)

The new non-mouldable resin can be readily sawed, drilled, turned, and even ground and polished on opticians' laps. It does not exhibit true plastic flow under heat and pressure, but may be bent to shape at 160°C. The tensile strength of the material at room temperature is 8,000 to 10,000 psi, and the hardness is 60-62 on a Rockwell C scale with a 68 kg. load and $\frac{1}{8}$ in. ball for 15 sec. Its stability to sunlight and ultra-violet light is excellent. Non-breakable eyeglasses are now being produced from this material by an optical company on an experimental basis.

A New High Temperature Alloy. (Mech. Eng., Vol. 62, No. 8, Aug., 1940, pp. 613-4.) (81/60 U.S.A.)

The Westinghouse Research Laboratories have produced a new alloy, containing only 7 per cent. iron, which is stronger than any known steel. It retains its

strength at temperatures higher than 2,000°F. The alloy, which is the result of almost seven years of research work, is actually stronger at 1,100°F. than ordinary low-carbon steel is at room temperature. Stranger still, it has a low damping coefficient—or in other words, it retains its elasticity at such elevated temperatures.

Almost half of K-42 B, as it is known, is nickel, and about a quarter is cobalt. Other components include chromium, titanium and iron. Production of the metal on a commercial scale is known to be practical, but its first cost will be high, and its immediate uses are expected to be those of a special-purpose alloy for dies, valves, steam fittings, and, possibly, turbine blades and other applications requiring temperature-resistant metals. It is reported that the new alloy "creeps" a great deal less than other metals in its class.

Hydraulic Drives in Industrial Service (Digest). (R. M. Schaefer, J.S.A.E., Vol. 47, No. 2, Aug., 1940, p. 28.) (81/61 U.S.A.)

Hydraulic drives are classified into two basic types:—

1. The positive-displacement type, which consists generally of a positive or variable-displacement pump and a constant-displacement hydraulic motor, either of the piston or of the eccentric type.

2. The turbo type, which depends upon the kinetic energy of the fluid discharged by an impeller or pump on the input side against the vanes of the turbine or runner.

It is explained that the turbo type depends upon the change of the kinetic energy of the fluid during its circulation, whereas the positive-displacement type depends upon the transfer of liquid under pressure at low velocity. For this reason the positive-displacement type does not have the shock-absorbing qualities that can be obtained with the turbo type. It is pointed out that all of the hydraulic drives which have been developed and applied recently in connection with internal-combustion engines are of the turbo type.

This paper demonstrates clearly the different performance characteristics that can be obtained with each of the two basic types of turbo hydraulic drive—the hydraulic coupling and the torque converter—when used in connection with internal-combustion engines.

A New Heat Transfer Liquid for Temperature up to 900°F. (Mech. Eng., Vol. 62, No. 8, Aug., 1940, p. 613.) (81/62 U.S.A.)

A new chemical mixture used as a heating and cooling liquid which will transfer heat up to 900°F. is described by engineers of the du Pont de Nemours Co. Consisting of approximately 40 per cent. sodium nitrite, 7 per cent. sodium nitrate, and 53 per cent. potassium nitrate, the mixture has a low melting-point, high heat-transfer rate, and a thermal stability and a lack of corrosive action on steel at temperatures above those obtained with Dowtherm, hot oil, or high steam pressure.

Obtainable in salt form, the solid material may be melted with 150 lb. steam pressure at 288°F., and when molten can be pumped like water.

Photographic Reproduction of Engineering Drawings on a Variety of Surfaces. (Mech. Eng., Vol. 62, No. 8, Aug., 1940, p. 617.) (81/63 U.S.A.)

A new process by which engineering drawings are directly reproduced, photographically, on nearly any kind of surface is now being used by the Glenn L. Martin Aircraft Co. An extremely large camera snaps pictures of large drawings, the negatives are developed, and the images projected back to large sheets of wood, metal, paper or cloth, whose surfaces have been sensitised with a special emulsion. When such a sheet—the maximum standard size is 5 × 10 ft., but it can be larger—is developed, the drawing appears in exact scale, or in fractional or multiple scales if it appears desirable. Fixtures, jigs, etc., are no longer built from small-scale drawings, but are constructed directly on the full-scale drawings themselves; the workmen simply follow the lines of the photographic print.

LIST OF SELECTED TRANSLATIONS.

NOTE.—Applications for the loan of copies of translations mentioned below should be addressed to the Secretary (R.T.P.), Ministry of Aircraft Production, Thames House, Millbank, S.W.1, and copies will be loaned as far as availability of stocks permits. Suggestions concerning new translations will be considered in relation to general interest and facilities available.

Lists of selected translations have appeared in this publication since September, 1938.

ARMAMENTS.

TRANSLATION NUMBER AND AUTHOR.		TITLE AND JOURNAL.
1061 Chevalier, R.	...	*Parachute Troops, French Ideas on Their Training and Use in the Field.* (Condensed from Revue d'Etudes Militaires, May, 1938.) (Luftwehr, Vol. 6, No. 10, Oct., 1938, pp. 392-8.)
1069 Beseler, J.	...	*The Armament of Enemy (British and French) Aircraft from Observations on Captured Material.* (Luftwissen, Vol. 7, No. 3, March, 1940, pp. 40-53.)
1075	...	*Balanced Gun Rings for Aircraft.* (German Patent 666, 783, C.22.02 of 22.2.31, published 26/10/38. Mechanische Werkstatten Neubrandenburg, G.M.b.H., Berlin—Britz.) (Flugsport, Vol. 30, No. 24, 23/11/38, Collection of Patents, pp. 126-7.)

AERO AND HYDRODYNAMICS.

1019 Gortler, H.	...	*The Transition from Subsonic to Supersonic Velocity in a Gas Flowing Through a Nozzle.* (Z.A.M.M., Vol. 19, No. 6, Dec., 1939, pp. 325-337.)
1048 Cremona, C.	...	*The Experimental Tank at the Guidonia Hydrodynamical Laboratory.* (Atti di Guidonia, No. 6, 30/4/39, pp. 85-104.)
1064 Prandtl, L.	...	*On the Calculation of the Boundary Layer.* (Z.A.M.M., Vol. 18, No. 1, 1938, pp. 77-82.)
1065 Gerber, A.	...	*Investigations into the Control of the Boundary Layer by Suction.* (Comm. Aerodyn. Institute Fed. Techn. Coll., Zurich, No. 6, Zurich, 1938.)

AIRCRAFT.

1066 Viola, T.	...	*New Methods of Calculation for the Determination of a Wing with a Special Form of Instability of Elastic Equilibrium.* (L'Aerotecnica, Vol. 20, No. 3, March, 1940, pp. 191-204.)

TRANSLATION NUMBER AND AUTHOR.		TITLE AND JOURNAL.
1070	Salzmann, F. ... Von der Muhll, A. ...	*Strength Investigations on Variable Pitch Propellers for Aircraft.* (Flugwehr und Technik, No. 3, March, 1940, pp. 65-8.)
1078	Schebel, F. N. ...	*Variations of Speed and Dynamic Pressure During a Vertical Nose Dive.* (L.F.F., Vol. 13, 1936, pp. 371-3.) (To be read in conjunction with M.A.P. Trans. 1,079.)
1079	Groth, E. ...	*Calculation of Nose Diving Speeds.* (Luftwissen, Vol. 7, No. 2, Feb., 1940, pp. 31-2.) (To be read in conjunction with M.A.P. Trans. 1,078.)
		ENGINES.
1059	Kollman, K. ...	*Limiting Factors in Single Stage Centrifugal Superchargers for Aero Engines.* (Luftwissen, March, 1940, pp. 54-61.)
1067	Himmler, C. R. ...	*New Methods of Distance Measuring and Control in Engine Tests on Altitude Test Benches.* (Luftwissen, Vol. 6, No. 5, May, 1939, pp. 157-162.)
1068	Himmler, C. R. ...	*Test Benches for Altitude Investigations.* (Luftwissen, Vol. 5, No. 12, Dec., 1938, pp. 432-6.)
1072	Hoock, T. ...	*A Comparison of Valve Mechanism (Poppet and Sleeve) as regards Limiting Values of Compression Ratio, Mean Effective Pressure and Specific Fuel Consumption.* (L.F.F., Vol. 16, No. 5, 20/5/39, pp. 276-82.)
1077	Hussmann, A. ...	*Vibrations in Helical Valve Springs.* (Jahrbuch der deutschen, L.F.F., Vol. 2, 1938, pp. 119-132.)
		MATERIALS.
1028	Voigt, W. ...	*On the Internal Friction of Solid Bodies, Especially Metals.* (Ann. d. Phys. XLVII, 1892, p. 671.)
		INSTRUMENTS.
1076	Ruden, P. ...	*Measurement of the Impact Pressure in Flight of a Monoplane, by Pitot Tubes in the Disturbance Zone of the Wing.* (Jahrbuch der deutschen, L.F.F., Vol. 1, 1938, pp. 588-610.)
		MISCELLANEOUS.
1029	Collatz, L. ...	*Approximate Methods for Calculating Characteristic Values.* (Z.A.M.M., Vol. 19, Nos. 4 and 5, Aug. and Oct., 1939, pp. 224-49 and 297-318.)
1060	Binz, A. ...	*Tasks of Chemical Science in the New Germany.* (Ang. Chemie, Vol. 47, No. 1, 6/1/34, pp. 1-11.)

ABSTRACTS FROM THE SCIENTIFIC AND TECHNICAL PRESS.

Issued by the

Directorates of Scientific Research and Technical Development, Air Ministry.

(Prepared by R.T.P.)

No. 82. SEPTEMBER, 1940.

Armament v. Speed as a Means of Defence for the Bomber. (T. Martucci, Riv. Aeron., Vol. 16, No. 4, April, 1940, pp. 35-46.) (82/1 Italy.)

The present day bomber is fitted with the same type of gun as the attacking fighter. The methods of sighting are no better, and as a result the aerial combat has to be fought out at close range (100-200 yards). To reduce vulnerability, the speed of bombers has been increased as much as possible and evasive tactics are employed unless a screen of protecting fighters is available. On account of the small endurance of the latter, this method of indirect protection seriously restricts the range of the bomber. If speed becomes the main protection, high aerodynamic efficiency of the fuselage necessarily leads to very cramped quarters of the crew and this reacts unfavourably if a gunnery duel becomes after all necessary.

For this reason the author favours the utilisation of large 4-engined bombers with good visibility and fitted with guns capable of accurate fire over a relative large range (2,000-3,000 yards). The sighting mechanism of such guns will necessarily be complicated and is best carried out by centralising the controls of all the guns. The gunnery officer would be stationed at a point ensuring good visibility and the guns, being controlled from a distance, could be arranged to give the best concentration of fire.

A large aircraft necessarily gives a steady platform and if necessary the turrets could be coupled so as to reduce recoil shock.

Provided such a bomber can spot the attacking aircraft at a sufficient distance, it should have little to fear from present day fighters. To deal effectively with them, new heavy fighters of the destroyer or cruiser class would have to be evolved. Such twin-engined fighters would have to carry heavy armament and rely on long range fire rather than on aerobatic qualities characterising the close range attack ruling at the moment.

Effect of Noises of Warfare on the Ear. (T. S. Littler, Nature, Vol. 146, No. 3,694, 17/8/40, pp. 217-219.) (82/2 Great Britain.)

The rapid development of high explosive weapons of destruction and attack, accompanied by increased blast effects, has necessitated increased protection against the possibility of physical injury.

The methods of protection of the ears against explosive sounds are very simple. One of these, the earplug, has probably been in use for more than a century and has always been used extensively by gunners and others in the presence of intense noise. The other is the buffer, which is a wedge of rubber or resilient material held between the teeth. It is believed to prevent the full shock of an explosion from being conveyed through the bones of the skull. Relaxation of the face muscles, in reducing the rigidity of any exposed part, is an additional protection which reduces blast effects. A supply of these such as cotton-wool soaked in "Vaseline" can easily be carried about the person as a precaution, and in the case of children pads strapped on the ears are an alternative. Earplugs made of hard material are not advisable as they are apt to produce irritation after long periods of use, and they have little advantage over more resilient obstructions.

Armour Plates for Aircraft. (Inter. Avia., No. 719, 22/7/40, p. 15.) (82/3 U.S.A.)

The installation of steel armour plates in nearly all the recent aircraft types in the course of this war has been found to offer excellent protection to the aircraft crews from machine gun and cannon fire. These plates, which in many cases are designed to form bulkheads or seat backs, protect the crew members mainly from head and chest injuries. The thickness of the plates ranges from $\frac{1}{4}$in. to $\frac{1}{2}$in.; the plates prevent the penetration of machine gun projectiles and splinters. Meanwhile, the U.S. Rubber Co. has developed a new type of aircraft armour plate of rubber and steel which is said to be about 20 per cent. lighter than all-steel armour plates. Tests have shown that the new material is capable of withstanding shots from various calibre ammunition even when fired at very close range. Details of the new invention are not available.

Respirators for Parachute Users. (Inter. Avia., No. 717-8, 15/7/40, p. 8.) (82/4 U.S.A.

The Mayo Clinic, Rochester, Minn., has announced a new pocket oxygen flask to the American Association for the advancement of science. The flask is a supplement to the ordinary oxygen system of the aeroplane and is intended for the use of military pilots forced to take to parachutes at great altitudes. It disconnects automatically when the pilot leaves the aeroplane by parachute; the oxygen supply contained in the flask is sufficient for ten to fifteen minutes.

Experiments on the Functioning of Wind Tunnel Honeycombs. (F. Schultz-Grunow and K. Wieghardt, L.F.F., Vol. 17, No. 3, 20/3/40, pp. 82-86.) (82/5 Germany.)

Wind tunnel investigations on boundary layer phenomena require a high degree of uniformity of the incident flow. Experiments were carried out on model honeycombs placed at an angle to the airstream, the deflection and velocity distribution of the exit air being investigated by means of a special form of pitot tube originally due to Prandtl. The model honeycombs consisted of a series of holes (3 mm. diam.) drilled out of solid plate of electron, the ratio of air passage to total area amounting to .721. By using plates of various thicknesses for the same hole pattern, the ratio t/d of hole depth to hole diameter could be varied from 8.33 to .167. It appears that for entry angles up to 12° the exit flow coincided approximately with the axis of the hole provided the ratio t/d is of the order of 5 to 6. For all values in excess of $t/d = .62$, however, a small negative deflection was found, *i.e.*, instead of issuing parallel to the hole axis, the exit air is deflected downward for an upward direction of the incidence. It is probable that this is due to boundary layer separation. The resistance coefficient of the honeycomb depends markedly on the t/d ratio, whilst change in Reynolds number produces no large effects.

Automatic Integrating Pressure—Traverse Recorder for Study of Flow Phenomena in Steam Turbine Nozzles and Buckets (with Discussion). H. Kraft and T. M. Berry, Trans. A.S.M.E., Vol. 62, No. 6, Aug., 1940, pp. 479-88.) (82/6 U.S.A.)

The high efficiency of modern steam turbines can be safely predicted only when the flow phenomena in all passages of the turbine are well understood. The General Electric Company maintains an air-test laboratory where these passages are studied over a wide range of conditions. The principal test is a series of impact-pressure traverses in an air stream simulating flowing steam. The test is a " contour-map survey " of emerging energy, formerly requiring thousands of observations. Recently an instrument has been built which automatically traverses the passage, calculates the corresponding flow and energy quantities, integrates them against the traversed path, and records the integrals in an easily readable manner. The high speed of the instrument increases greatly the range of possible tests. Its inherent accuracy of 0.1 per cent. surpasses the best previous performance. The instrument, using mechanical devices for measuring, calculating, and integrating, has all moving parts controlled by electric and photoelectric means.

An Investigation of Energy Losses in Steam Turbine Elements by Impact Traverse Static Test with Air at Subacoustic Velocities (with Discussion). (W. R. New, Trans. A.S.M.E., Vol. 62, No. 6, Aug., 1940, pp. 489-502.) (82/7 U.S.A.)

Efficiency of any turbine stage depends upon many variables. Blade pitch, orientation, height, and velocity ratio among purely geometrical quantities, and effects attributable to compressibility and viscosity of the medium all deserve special consideration. Investigation of energy losses as functions of the key variables is accomplished statically on various forms of equipment among which the impact-traverse tester is considered an important type. The necessary and sufficient conditions to be satisfied by the static test, in order that it represent fully dynamic conditions, are (*a*) the flow relative to the given static element must be at all points the same in magnitude and direction as it would be if the element were in uniform rotation relative to the flow in a turbine; (*b*) output of the element measured statically must differ from power only by the linear-velocity term eliminated by the static test. The apparatus, procedure, and results attained in meeting these test requirements are explained by the author.

Laminar Flow Heat Transfer Co-efficients in Ducts (with Discussion). (R. H. Norris and D. D. Streid, Trans. A.S.M.E., Vol. 62, No. 6, Aug., 1940, pp. 525-533.) (82/8 U.S.A.)

In this paper, theoretically derived values of the heat-transfer coefficient for flat ducts with constant surface temperature are presented and compared with the corresponding results for round ducts which have been previously published. A few test data for air in flat ducts are compared with the theoretical results. For both flat ducts and round ducts the results are presented both in customary terms and in terms of the logarithmic-mean temperature difference. The latter results provide a consistent basis for comparisons with heat-transfer data for turbulent flow. Some limiting values of the local heat-transfer coefficient for both constant surface temperature and constant heat input per unit length are tabulated, and some equations pertinent to very short ducts are included.

Problems of the Transport Service in the U.S.S.R. (L. A. Tsekhanovitch, Civil Aviation, U.S.S.R., Vol. 8, No. 4, April, 1938, pp. 9-14.) (82/9 U.S.S.R.)

1. Loads of an urgent nature should be sought, whose conveyance by air is justifiable on the grounds of national economy.

2. Attention to the comfort of *passengers* is a further problem needing attention.

3. The *mails* require utmost punctuality and careful handling and attention. Apparently, insufficient care has been taken of the mails hitherto, with the result that the Postal Service frequently do not employ the air lines to the extent possible.

4. In *goods* traffic the importance of careful attention and punctual service is likewise emphasised. Here, also, conditions have apparently been unsatisfactory, there is particular need of a more conscientious attitude towards prompt re-forwarding of consignments (also by alternative means of transport in case of an interruption of the air service), and some form of despatching system is suggested.

It is essential that full responsibility be assumed for delays, mistakes in despatching, loss and damage, etc. An indication of the possibility of sabotage in this direction is given. The conclusion is drawn that efficient working, largely if not exclusively, depends on personnel—of all grades—and that better training and instruction thereof, as well as proper commercial methods in general, are the prime requisites for all improvement.

The Civil Air Fleet of the U.S.S.R. (V. S. Molokov, Civil Aviation, U.S.S.R., Vol. 8, No. 8, August, 1938, pp. 1-6.) (82/10 U.S.S.R.)

Figures are given, of the expansion of civil air routes, from 420 km. at the establishment of the first air line from Moscow to Orel in 1923, to 106,100 km. of aerial routes, existing at 1st June, 1938. This is compared with 103,000 km. air lines in the U.S.A., 62,000 km. in France, and 37,500 km. in Britain.

High speed aircraft for passenger and mail services are now in use on the main routes. An " Express " service between Moscow and Khabarovsk is being established, reducing the journey time from 4-5 days to two days.

Traffic has increased from 200 passengers, 1.8 tons mails, and 0.1 ton goods in 1923, to 203,200 passengers, 9,000 tons mails, and 36,400 tons goods, in 1937. The two " Five-Year Plans " in particular, have brought an extraordinary development of the air services of the U.S.S.R. Passenger traffic has increased 1,000 times!

In addition, the Civil Air Fleet maintains " special " services for agricultural needs, health protection, forestry, fisheries, and other ancillary services. The area dusted with insecticides, has increased from 2,500 hectares in 1925, to 900,000 hectares planned for 1938. Anti-malarial applications increased from 8,500 ha. in 1929 to 3,000,000 ha. in 1937.

The Economic Alignment of Aerial Routes. (V. M. Parakhousky, Civil Aviation, U.S.S.R., Vol. 8, No. 8, August, 1938, pp. 23-29.) (82/12 U.S.S.R.)

The development of aerial transport in any country depends on the proper economic alignment of the necessary air services.

Such ties or connections need not be invariable, and the exceeding flexibility of aerial transport as such should, therefore, be freely utilised to ensure that the alignment of the routes served will always correspond to the needs of the moment in regard to the available demand for transport services. Abandonment of services no longer justified by economic, administrative, or cultural needs, or the alteration of their alignment, should therefore be freely practised.

Air transport in the U.S.S.R. is by now so far developed as to raise the question of inaugurating " through " and " express " services on the main routes. This development will be helped by the increasing flying range of modern commercial aircraft, permitting many intermediate calls, originally instituted for service reasons, and not for traffic needs, to be omitted.

The alternative proposal to establish a network of "radial" main lines, on the principle of shortest flying distance without regard to traffic needs, with "feeder" lines where necessary, tapping outlying traffic sources, is examined and found unsuitable.

Examples are given in support of the various points raised above.

Arctic Aviation. (J. P. Mazuruk, Civil Aviation, U.S.S.R., Vol. 8, No. 8, August, 1938, pp. 7-11.) (82/11 U.S.S.R.)

The first (Russian) flight into the Arctic regions was made by Nagursky in 1914.

The U.S.S.R. inaugurated Arctic aviation in 1925, from which year until 1929, experimental flights of an occasional nature, were made. This stage concluded with the brilliant rescue of the Nobile expedition.

From 1929 to 1932 systematic work was done on the investigation of ice conditions in the Kara Sea and elsewhere, in connection with the Arctic sea route.

With the formation of the Northern Sea Route Administration (1933), Arctic aviation has carried out extensive and important operations, not limited to the coasts and islands of the Russian Arctic seaboard, but extending also over the Polar basin to America.

Some figures are given:—

Flying hours	... ...	25,712
Divided into:—		
Exploration ...	... ...	2,232 hours
Air lines ...	... ...	18,100 ,,
Other services	... ...	5,380 ,,
(Ice patrol—1,050 hours.)		
Traffic data:—		
Mileage of air lines	...	11,977 km.
Number of journeys	...	1,590
Passengers, number	...	14,819
Mails, tons ...	... ...	212
Goods, tons ...	... ...	615.8
Ton-kilometres	... ...	1,700 thousand

Among the special duties carried out, was the transportation of some 1,000 tons of goods for a "metal combine" plant situated far beyond the Arctic Circle.

Some Questions in the Establishment of Air Lines. (A. Sokolov, Civil Aviation, U.S.S.R., Vol. 9, No. 7, July, 1939, pp. 41-42.) (82/14 U.S.S.R.)

The introduction of new high speed material on the air lines of the U.S.S.R. impels a reconsideration of the method of planning and arranging air services, with regard to the spacing of intermediate flying grounds in particular.

A formula for calculating the optimum spacing of intermediate landing points is given as follows:—

L = length of uninterrupted flying distance, in km.
Q = total load of the aircraft.
V = cubic contents of the goods compartment.
S = average density of goods normally conveyed by the air line.
K = coefficient of useful load of goods compartment.
P = weight of service load (crew, etc.).
f = weight of lubricating oil.
g = fuel expenditure per kilometre flying distance.
m = navigational fuel supply, per cent. of load.

$$L = (Q - VSK - P - f)/g\,(1 + m)$$

In the case of a purely passenger-carrying aircraft, (VSK) comprises the weight of passengers and baggage.

Obviously, this optimum length of non-stop flight will not always correspond to the actual spacing of suitable calling points on the route. In such a case, the best adjustment in accordance with the fuel endurance of the individual aircraft should be made. A means of doing this by graphical methods is described.

Servicing Air Passengers. (N. A. Rynin, Civil Aviation, U.S.S.R., Vol. 9, No. 7, July, 1939, pp. 20-22.) (82/13 U.S.S.R.)

The author deals with the publicity and propaganda necessary to attract passenger traffic to the air lines lays particular stress on *physical comfort* and the avoidance of air sickness. In this connection, the following table is given :—

Factors.	Limit of discomfort.	Limit of comfort.
Flying height, metres	4500	3000
Pressure, mm. mercury	430	525
Falling speed, m./sec.	5	1-2
Climbing speed, m./sec.	22	14
Acceleration, g. vertical	1	0.1
Acceleration, g. centrifugal	4.5	1.5
Angles of motion	20°	5°
Vibrations, amplitude, mm.	1.27	0.23
Cold, degrees C.	−1	+17
Heat, degrees C.	+45	+17
Ventilation, per head, litres/min. ...	140	300
Ventilation, velocity, m./sec.	6	1
Oxygen content, per cent.	13.5	18
Carbon dioxide, per cent.	6.5	2
Noise, decibels	120	85
Space per person, cub. m.	0.5	1.6
Space per person, sq. m.	0.4	1.0

Turning to the psychological factors affecting the attitude of passengers towards air travel, the importance of politeness and attention on the part of the staff is stressed. The cabin should contain route maps, information on the route, and a first aid cabinet.

Finally, the importance of servicing at starting point, interchange points and at destination (with particular attention to quick transportation to and from the flying field, handling of luggage, etc.) is stressed.

Civil Aviation and Defence. (V. S. Molokov, Civil Aviation, U.S.S.R., Vol. 9, No. 8, August, 1939, pp. 7-12.) (82/15 U.S.S.R.)

What will be the defensive tasks of the Civil Aviation of the U.S.S.R.?

Particularly important will be its rôle as a mighty reserve of personnel for military aviation.

The whole flying and technical personnel of the Civil Aviation Fleet must be trained to a level as high as that of the Red Air Fleet.

This important work is in the hands of a special section for battle training. Pilot personnel are trained on high speed aircraft, and their navigational training perfected. Furthermore, formation flying, battle flight, air gunnery, and bombing practice are undertaken. Technical and ground staffs undergo a similar supplementary training.

The important tasks falling to the lot of the Civil Air Fleet in time of war require that already now, safety, regularity, and the maximum of accuracy in transport work should be aimed at in all sections of civil flying.

Many leading workers, commanders, and leaders in the Civil Air Fleet will have to be prepared to take their places in the Air Force on the outbreak of war. They should already now be training and preparing their substitutes for that case.

Massed defence training should be extended to all branches of the Civil Air Fleet. Not one worker therein, but should have his wartime speciality, should have passed his tests in anti-aircraft and anti-gas defence, and should be able to handle a rifle or machine gun. Workers in flying sections, airports, repair bases, should be trained in the anti-aircraft defence of their own units, all should know their places, tasks, and responsibilities in the case of an air raid warning.

Measures for Reducing Airscrew Noise. (G. Weymann, L.F.F., Vol. 17, No. 3, 20/3/40, pp. 89-96.) (82/16 Germany.)

The details of a new search tone analyser are given. In this device the sound to be analysed modulates the oscillations of a tube generator and the resultant side bands are passed to a filter which responds whenever the sum of the noise frequency and the adjustable generator frequency equals that of the filter. The filter frequency is amplified and the amplitude measured after rectification is proportional to the amplitude of the particular noise frequency.

If f_g = noise frequency;
f_s = search tone generator frequency;
f_F = filter frequency;
$f_g = f_F - f_s$.

By altering f_s slowly, the noise frequencies are thus obtained in succession.

Making use of this apparatus, the author investigated the sound spectrum of a rotating model airscrew and demonstrated that the so-called " sound of rotation " can be considerably reduced by ejecting high pressure air through the propeller tips and thus reducing the pressure discontinuity existing in this region. Unfortunately the required discharge speed of the air is bigger than can be produced by natural aspiration through the propeller hub (suitably modified) and a separate air supply is thus required. By working at a sufficiently high pressure (small discharge holes), an appreciable sound reduction can, however, be obtained with relatively small quantities of air, without affecting the aerodynamic efficiency of the airscrew. An alternative method investigated theoretically by the author, consists in operating two suitable propellers in close proximity. It appears that this arrangement will produce a considerable noise reduction in certain directions.

Operations and Accidents of American Air Carriers during 1939. (Inter. Avia., No. 717-8, 15/7/40, p. 16.) (82/17 U.S.A.)

The Civil Aeronautics Authority has published the final statistics of operations and accidents of the American air carriers during 1939. The foreign operational results are not included in the figures for the twelve months period. *Operations*: 82,571,523 revenue miles flown (1938: 69,668,827); 1,717,090 revenue passengers (1938: 1,176,858); 9,514,299 lb. express (7,335,967 lb.); 17,169,782,735 mail lb.-miles flown (14,845,719,671 lb.-miles). *Accidents*: During the year a total of 33 accidents occurred on domestic services and six on the foreign and territorial services, making a total of 39. They cost the lives of two pilots, two co-pilots, three other crew members, and 19 passengers, making a total of 26. The nature of the accidents was as follows: 17 landing accidents, nine taxying accidents, two take-off accidents, three forced landings, and the remainder miscellaneous.

Escher Wyss Variable Pitch Airscrew. (Inter. Avia., No. 717-8 (Supplement), 15/7/40, pp. 1-4.) (82/18 Switzerland.)

The airscrew is operated hydraulically (engine oil) and an important new element in the control hub is the ingenious automatic locking device for all blades which is built into the control cylinder. Should the oil pressure fall below a determined value owing to damage to the oil supply system or also to deliberate release by the pilot, the locking apparatus instantaneously and in any position prevents any further axial motion of the control cylinder built into the hub and,

thus, of the airscrew blade. The airscrew is then ready to operate in the manner of fixed pitch types. This provides the desired freedom from blade hunting around the longitudinal blade axis and makes possible in the case of steady loads, *e.g.*, under cruising conditions, an automatic relief of the oil and servo motor systems and a corresponding economy in energy. The locking device operates so accurately and instantaneously that it responds also to the slightest load variations. When the airscrew is employed as a brake producing negative thrust, such a safety device, which simultaneously prevents the blades from inadvertently returning to negative pitch settings, is highly important. At its forward end, the control cylinder carries a ring with articulated connecting rods, which transmit the pitch adjusting forces to the blade sockets and thus cause the axial rotation of the blades. The simple construction employing connecting rods for the transmission of the forces gives a connection which operates without play for practically unlimited periods.

The entire locking mechanism is attached to the fixed piston in the interior of the hub and completely submerged in oil. Before the pressure oil reaches one or the other face of the piston it operates small spring-loaded auxiliary pistons whose motion actuates locking parts which can mesh with corresponding parts in the interior of the control cylinder. When the pressure oil arrives it first releases the spring-loaded locking devices between piston and cylinder; only then it can flow into the lines leading to the forward or the rear chamber of the control cylinder and axially displace the cylinder. The entire apparatus is automatically operated by the governor oil but can be switched over to manual operation by the pilot at any time.

Although the Escher Wyss hub contains this additional apparatus which is not featured in current types of airscrews, its exterior shape is not clumsy or bulky. Special care has been taken to provide facilities for the easy assembly and removal of the individual parts. The blades are readily screwed in or out from the outside without necessitating the dismantling of the controllable mechanism located in the centre. On the other hand, the pitch adjustment and locking apparatus may be taken out of the hub and replaced after the removal of the hub front inspection plate. As a result of the methodical development and in spite of the wide pitch angle range the weight of the airscrew is remarkably low. (The complete three-blade airscrew for 1,000 to 1,200 h.p. weighs about 270 lb. = 122 kg., the complete auxiliary unit about 9.5 lb. = 4.25 kg.)

Recent Developments in Propeller Blade Design. (L. H. Enos, Aero Digest, Vol. 37, No. 2, Aug., 1940, pp. 48-51.) (82/19 U.S.A.)

During the past year, means of reducing propeller blade weight have been given considerable attention. The lower weight of hollow welded steel blades as compared to the 25 S aluminium alloy blades has led to the development of a new aluminium alloy with higher strength characteristics.

The characteristics of this new alloy (X 76 S) are given below:—

TABLE I.

	25 S	X 76 S
Ultimate strength (p.s.i.)	58,000	73,000
Yield point (p.s.i.)	38,750	65,000
Reduction of area (per cent.) ...	31-38	35
Elongation (per cent.)	16	15
Brinnel	100	147
Fatigue smooth specimen (p.s.i.)...	15,000	20,000
Specific gravity	2.79	2.79
Fatigue stress sp. gr.	5,380	7,170

From the increased allowable fatigue stress of the X 76 S alloy as compared to the 25 S, it would at first appear that a large reduction in weight can be

made. There are certain features of design, however, which restrict taking the fullest possible advantage of this improvement, and the hollow steel propeller is still appreciably lighter.

During the past year improvements in manufacture and design of hollow steel blades have been achieved.

Since the Curtiss hollow steel blade is made up of two sections welded together it is necessary that the steel possess desirable welding characteristics. The welding process used is the atomic hydrogen process which gives a high strength uniform weld. Physical characteristics of the steel used for both virgin and welded portions are given in Table II.

TABLE II.

	Virgin Stock.	Weld Stock.
Ultimate tensile strength (p.s.i.) ...	145,000	115,000
Yield point (p.s.i.)	131,000	109,000
Reduction of area (per cent.) ...	59	50
Elongation (per cent.)	14	10
Rockwell " C "	31	21
Fatigue smooth specimen (p.s.i.)...	83,000	60,000
Specific gravity	7.9	7.9
Fatigue stress sp. gr.	10,500	7,600

A further advantage of the hollow steel propeller lies in the fact that blade shank fairings or cuffs can be easily fitted.

With aircraft engines giving increasing powers and with the stringent requirements as to allowable cylinder temperature, better cooling from the propeller has become necessary. Cuffs have assisted greatly in the problem of using the increased engine powers without additional cowl opening or increasing the size of the cowl flaps. Designers who have seen the results of cuffs on their installations are taking advantage of the improvement by fitting the smallest possible cowl. On one typical single engine installation the addition of cuffs to the propeller which was fitted with a fair sized spinner resulted in the following average reduction of temperature, on the ground: Cylinder head 40°C., cylinder base 10°C., the spark plug elbows 16°C. During climb the reduction was much less, and at V_{max} no difference was noted. Because of the smaller cowl possible with cuffs the V_{max} was increased 1 per cent. which was equivalent to 25 thrust h.p. The cuff installation weighed 10 lbs.

Servo Operation of the Control Surfaces of Large Aircraft. (E. W. McDonough, Aero Digest, Vol. 37, No. 2, August, 1940, pp. 76-80.) (82/20 U.S.A.)

Pre-requisites of a booster control system may be summarised as—(1) use of conventional type control levers; (2) necessity for only a moderate control force by the pilot; (3) the presence of a certain amount of " feel " of the actual forces existing on the control surface; and (4) direct connection to control surfaces to provide a means for actuation in the event of hydraulic pressure failure.

Two available methods offer a solution to this problem; they may be classed as the " displacement feel," and the " load feel." In the former design, movement of the controls opens servo valves which immediately allow pressure to build up in the Sperry gyro pilot cylinders. This causes the control surfaces to move to a position determined by the amount of movement in the controls.

The " displacement feel " system is disadvantageous in that it gives the pilot finger-tip control which may be dangerous in a quick emergency manœuvre. Furthermore, the pilot must learn to fly by displacement of the controls and the aeroplane's response to that displacement; the system not only lacks the cus-

tomary " feel," but also control resistance is artificially built up by friction and springs.

On the other hand, the " load feel " system retains all the characteristics of mechanical control, the pilot " feeling " only a fraction of the resisting force as in the mechanical system. The mechanical characteristics of this system are aided by hydraulic power which can be designed to give any desired degree of assistance to the pilot.

Wright Field High Speed Wind Tunnel. (Aero Digest, Vol. 37, No. 2, Aug., 1940, p. 120.) (82/21 U.S.A.)

Largest high speed wind tunnel in the world is being constructed for the U.S. Army Air Corps at Wright Field. Its test chamber section, according to specifications prepared by the Air Corps, will be 20 ft. in diameter with a maximum air speed of 400 m.p.h. The tunnel will be large enough to take full-size fuselages, cowls, canopies, nacelles, and propellers.

Complete plans call for a tunnel tube, circular in cross section, extending around the four sides of a rectangle to form a circuit one-seventh of a mile; a test chamber building built around the tube on one of the long sides of the rectangle; and an adjacent power building which will house the largest electric motor ever used to power a wind tunnel.

Weighing 249,000 lbs. and developing 40,000 h.p., this motor will drive two 40 ft. fans in tandem.

New Type of Structure for Aeroplane Hangars. (Aero Digest, Vol. 37, No. 2, Aug., 1940, pp. 142-145.) (82/22 U.S.A.)

Development and construction of a welded knee has made possible an economical type of construction applicable to hangar structures. Among the advantages of the employment of this design are a higher strength to weight ratio, savings in material, and speed of construction. Contrasted with the conventional girder and joist construction, the weld design saves about 20 per cent. in height and ceiling space, and about 33 per cent. of the cubic footage. The reduction of this area results in savings in heating, and the low ceiling minimises the danger of fume accumulations.

Other advantages claimed for this design are: Savings of about 15 per cent. in the total weight of the steel over a given area; and savings of from 18 to 22 per cent. in the cost of labour for its erection.

The welded steel frames are stress-relieved at the factory, and their fabrication in the field is achieved by welding.

The design is also applicable to underground hangar construction, and arrangement for the utilisation of either an elevator or ramp by means of which aeroplanes may be moved to and from ground level, can be incorporated. The elevator construction is so arranged that when the lift is raised it is flush with the ground level; when it is lowered it is flush with the floor.

Some Aspects of Airscrew Design. (H. L. Milner, Aeronautics, Vol. 3, No. 2, Sept., 1940, pp. 64-70.) (82/23 Great Britain.)

The diameter D of an airscrew of optimum efficiency is given approximately by the equation

$$D = k\,(P_1/vn^2\sigma)^{\frac{1}{4}} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where v = speed of flight in feet/sec.
n = r.p.s.
σ = relative density (sea level = 1).
P_1 = h.p. $\times$ $\{ 2 + 0.07\,(B-2) \}$ /B.
B = number of blades.
k = constant = 42 app. for blades of normal shape.

An increase in h.p. thus does not lead to an increase in diameter, if the product vn^2 can be increased sufficiently. Both v and n determine, however, the resultant tip speed C of the airscrew which must not exceed 0.9 times the velocity of sound, as otherwise there is a serious drop in efficiency. For constant values of P_1, C and σ, it is easily shown that the diameter D will be a minimum, if $v^2 = \frac{1}{3} C^2$. With $C = 967$ feet/sec., v then becomes 381 miles per hour. At both higher and lower translational speeds, the diameter of the optimum propeller will be greater than this minimum. The actual diameter will, of course, depend on the number of blades and their shape, but provided the blades are similar, minimum diameter will correspond to $v = 381$ m.p.h. irrespective of h.p. and altitude. It thus appears that the maximum speed range of modern aircraft favours the airscrew manufacturer since his product is operating at the optimum specific weight ratio (minimum diameter).

At higher operational speeds, however, the diameter (and therefore weight) of the optimum propeller will increase rapidly. This increase is practically independent of the number of blades fitted.

The only way of overcoming this difficulty would be to increase the blade width and sacrifice a portion of the ideal efficiency.

The Harmonic Analysis of Valve Lift Diagrams. (K. Schaefke, L.F.F., Vol. 17, No. 3, 20/3/40, pp. 87-88.) (82/24 Germany.)

The author describes a new method of analysing valve lift diagrams, which depends on a series solution for the fundamental integrals

$$\int f(x) \cos \mu x dx \text{ and } \int f(x) \sin \mu x dx.$$

The members of these series depend primarily on the discontinuities of the function $f(x)$ and can be readily obtained provided the position of these discontinuities is known.

The solution is mathematically exact if the derivatives of $f(x)$ vanish for higher orders. This generally is the case, since most valve acceleration diagrams are made up of a series of straight line sections.

The new method is illustrated by means of a worked out example which demonstrates the advantages claimed.

Guiberson A. 1020 *Aircraft Diesel Engine (Nine-Cylinder Air-Cooled Radial).* (Inter. Avia., No. 716, 29/6/40, pp. 6-7.) (82/25 U.S.A.)

Data of the engine: Bore, 5.125 in.; stroke, 5,500 in.; total displacement, 1.021 cu. in. (16.73 lit.); compression ratio, 15 : 1; rated power output, 320 h.p. at 2,200 r.p.m.; take-off power, 340 h.p. at 2,250 r.p.m.; output per cu. in., 0.313 h.p.; B.M.E.P. at rated horse-power, 113 lb./sq. in.; fuel consumption, 0.38 lb./h.p./hr. at full rated power and 0.34 lb./h.p./hr. at cruising power of 190 h.p. at 1,800 r.p.m. Engine diameter, 47 in.; weight, 620 lb. As has been reported a 250 h.p. military version of the engine, designated "T-1020, Series 3," is available for tanks and other vehicles.

Each cylinder has a spring-loaded fuel injector with a triple orifice nozzle which sprays the fuel fanwise through three holes 0.014 in. in diameter. The fuel is injected at a pressure of from 2,200 to 2,500 lb./sq. in. An individual fuel pump is assigned to each cylinder; these pumps are of the Guiberson vacuum type which was specially developed with a view to simplicity and the elimination of the need for a governor or other complicated mechanism. The fuel inlet of the pump is controlled by the plunger; the time of opening of the inlet port and thus the amount of fuel admitted change in accordance with the throttle setting. The fuel flow to the pump is increased by the vacuum created in the pump during the down stroke of the plunger.

Schweitzer Aircraft Diesel Engine. (Inter. Avia., No. 717-8, 15/7/40, p. 8.) (82/26 U.S.A.)

Development of a Diesel engine adaptable for use in aircraft has been announced by Dr. P. H. Schweitzer, of Pennsylvania State College, before the American Society of Mechanical Engineers. The experimental engine is equipped with a tank out of which liquid oxygen is injected into the air intake at the take-off of the aeroplane. The procedure is said to increase the efficiency of the engine by 35 per cent. at the take-off period and will enable the use of Diesels one-third smaller and lighter than at present.

Octane Rating of a Number of Pure Hydrocarbons and of Some of Their Binary Mixtures. (J. Smittenberg, H. Hoog, B. H. Moerbeek and M. J. v. d. Zijden, J. Inst. Petrol., Vol. 26, No. 200, June, 1940, pp. 294-303.) (82/27 Great Britain.)

The octane rating of 50 pure hydrocarbons (purity at least 98 per cent.) was determined by the C.F.R.—A.S.T.M.—motor methods using *n*-heptane and iso octane as reference fuels. Extrapolation of the octane scale below zero and above 100 was carried out by noting the height of the compression chamber for standard knock intensity. Ratings above that of iso octane (100) were obtained for the following paraffins:—

Methane	110
Ethane	104
2.2.3. trimethylpentane	102
2.2.3.3. tetramethylbutane	103

Negative octane ratings are given by

n-octane	−17
n-nonane	−45

The only aromatics tested (benzene and toluene) had ratings of 108 and 104 respectively.

In the case of binary mixtures, the octane rating does not always follow the straight line law of mixtures, but the first small additions may produce a disproportionally large effect on the octane rating. This is especially marked in the case of addition of di-isobutylene or hexadiene to *n*-heptane.

Measurements of Noise and Vibration. (H. H. Scott, Proc. Inst. Rad. Engs., Vol. 28, No. 6, June, 1940, pp. 284-285.) (82/28 U.S.A.)

New developments have extended the field of sound measurements to corresponding equipment developed mainly for vibration measurements.

In chronological order, these developments have been essentially: (1) The vibration pick-up for attachment to a standard sound level meter; (2) a control box allowing variation of the frequency characteristics of the pick-up sound meter combination to provide acceleration, velocity, or displacement characteristics at the will of the operator; (3) development of a special instrument for vibration measurements, known as a vibration meter, and covering a range down to two cycles per second; (4) development of an analyser similar to the sound analyser, but intended for the vibration frequency range; (5) development of a complete recording assembly, consisting of vibration meter and automatic recording analyser. Such a device provides maximum convenience and furnishes completely inked curves showing the analysis of practically any type of vibration of the basis of vibration acceleration, velocity, or displacement.

Vibration measurements are now in the state where noise measurements were six or eight years ago. The present equipment is very useful, but there are many possibilities of improvement.

Fuel Consumption Meter. (Aero Digest, Vol. 37, No. 2, August, 1940, p. 146.) (82/29 U.S.A.)

The instrument can be used in actual plane operation or on engines on the test block. A control switch permits instant starting or stopping of measurement without interfering with continuous supply of fuel to the engine.

A dial electrically records each 1/100th part of a gallon, while fractional parts are readable by 1/1000ths, on a translucent measuring cylinder. Measurement is by positive displacement with air or vapour automatically eliminated so that only solid fuel is measured.

The instrument has an integral pumping system capable of supplying 20 gals./hr., and is designed for use on either 6- or 12-volt systems. Accuracy or operation are not affected by extreme vibration conditions. Extreme accuracy of measurement and flexibility of control make the instrument ideal for study of fuel consumption under varied conditions. A thermometer provides fuel temperature reading for correction factor where desired.

Gyromatic Navigator. (Aero Digest, Vol. 37, No. 2, Aug., 1940, p. 153.) (82/30 U.S.A.)

This instrument combines the functions of the automatic radio direction finder and the directional gyro, integrates their combined indications with reference to the aircraft's heading, and provides for the pilot at a glance a continuous and graphic solution of several complex problems in radio navigation. Many navigational problems which could not be solved with the equipment heretofore available are automatically resolved by the gyromatic navigator.

Both radio and directional gyro bearings are indicated against a single 360° azimuth scale, divided into equal degree marks. The scale is rotatable by hand, and may be set for any given course, as shown by the fixed lubber line. Radio bearings (and their reciprocals) are indicated by a double-ended pointer actuated by the automatic radio direction finder. Directional gyro bearings are indicated by a lubber line etched into a transparent rotating disc, placed above the radio pointer and actuated by the directional gyro within the instrument housing; gyro caging and setting controls are provided on the instrument case. The miniature reference aeroplane and its lubber line are etched into the fixed glass cover of the instrument; a fixed east-west variation scale is provided on the case for ready reference.

In operation, the pilot uses either the radio or the gyro bearing as his primary reference, depending on the nature of the navigational problem, and uses the other bearing as the cross reference. The two bearings, read against the fixed lubber mark, give the pilot a continuous graphic picture of his heading with respect to one or more radio stations and his desired track.

For instance, in flying a course directly towards or away from a radio station, on a given course, the radio and the gyro bearings will coincide with the reference lubber mark so long as no drift is present. Under drift conditions, the radio and the gyro bearings will diverge, indicating to which side off the course the aeroplane is drifting. The pilot may then return to the originally plotted course by steering a heading towards the diverging radio bearing, and at a slightly greater angle, until the two bearings again coincide.

In position finding, a fix is obtained by plotting on a map the reciprocals of two successive radio bearings, on two stations not in a straight line with the aeroplane; and the directional gyro is then set for the desired course from that position to destination. The entire operation, including plotting, occupies less than one minute. It should be noted that in turbulent air the angle between the radio and the gyro bearings always remains steady and constant for a given position, facilitating navigation.

A New Synthetic Rubber "Gaco." (Les Ailes, No. 984, 6/6/40, p. 5.) (82/31 France.)

The new material is derived from acetylene and is unaffected by contact with fuel and may even stand immersion in oil at temperatures of the order of 300° C. Under the action of excessive heat, the material does not soften like ordinary resins, but hardens and eventually carbonises.

At ordinary temperatures, "Gaco" is very pliable and at the same time resists abrasion. It can be moulded in the hot state and is specially suitable for the construction of high speed couplings. It has also stood up well in hydraulic and pneumatic installations.

By means of a special process, "Gaco" can be fixed to metallic surfaces and thus produce an excellent oil seal.

Crippling Load of Euler Columns. (C. Riparbelli, Atti di Guidonia, No. 11, 20/6/39, pp. 217-240.) (82/32 Italy.)

In the design of girder-type fuselages built up of welded steel tubing, it is necessary to calculate the crippling load of each member that is not subjected to tension alone. The normal procedure is to calculate the crippling load as if the columns were hinged at each end and then to multiply it with a "rigidity" factor, estimated by the designer.

The object of the paper is the determination of a "rigidity" factor which will relate the crippling rigidity of a strut to the rigidity of the adjoining ones.

The method is simple and yet rigorously correct, once the assumptions have been made that (*a*) the strut is of the Euler type, (*b*) the elastic line is a sine curve.

To extend the theory to the case of non-Euler struts, the concept of equivalent strut length is introduced, being the length of a strut, hinged at both ends, having the same cross-section but minor length, the latter being equal to half the wave length of the elastic line. If the wave length of the elastic line is known, then the crippling load of the strut under consideration will be the crippling load of the equivalent hinged strut, whose length is half that wave length.

In order to determine the wave length of the elastic line in the case of a non-Euler strut, the further assumption is made that the theory evolved for the Euler strut is still applicable, so far as the determination of the wave length is concerned. Instead of the Euler formula, the crippling load of the equivalent strut is then determined by means of the available tables compiled from experimental data.

The author states that the last assumption has been confirmed experimentally.

Swelling of Synthetic Rubbers in Mineral Oils. (F. H. Carman, P. O. Powers and H. A. Robinson, Ind. and Eng. Chem. (Ind. Ed.), Vol. 32, No. 8, Aug., 1940, pp. 1069-1072.) (82/33 U.S.A.)

1. There is a marked difference in the swelling caused by different mineral oils on compounds made of any synthetic rubber, such as Neoprene, Thiokol, or Perbunan; the arrangement of the oils by swelling effect tends to remain the same for the synthetic compounds tested.

2. The change in volume is rapid on initial immersion and then gradually approaches equilibrium, except in the case of those systems where marked swelling is encountered.

3. The aniline point, determined at a concentration of equal parts of aniline and oil by weight, appears to be a characteristic of mineral oil which will indicate the probable swelling effect on synthetic rubber compounds. The 50 per cent. aniline point is more conveniently determined than is the gravity index and appears to be at least equally reliable.

4. The viscosity rating of a mineral oil is not a satisfactory criterion of its tendency to swell rubberlike compositions and should not be the sole description of an oil for acceptance specification testing of synthetic rubber products.

Powdered Metal Matrix (Cu-Ni) for Bonding Babbitt to Steel. (R. P. Koehring, Metal Progress, Vol. 38, No. 2, August, 1940, pp. 173-176, 196.) (82/34 U.S.A.)

Both tin base and lead base babbitts have low resistance to fatigue. Experience shows that cracking and actual breaking out of the bearing surface is more likely to occur if the babbitt layer is thick. Thin layers are, however, difficult to use unless the bonding is very secure. The new process utilises the technique of powder metallurgy to sinter and braze to the steel back a matrix composed of a mixture of 60 per cent. Cu and 40 per cent. Ni powder. The porous structure produced in this way gives secure support to the babbitt, both chemically and by mechanical interlocking. It is thus possible to utilise a layer of babbitt only 0.002 in. thick, which is completely free from any fatigue effects. Details of the manufacturing process are given, strips of steel passing through the various operating machines in turn, the process thus being continuous. In order to ensure optimum bonding, the babbitting of the sintered deposit is carried out in vacuo (absolute pressure 6-7 mm. Hg.).

From the babbitting machine, the strip goes to a milling machine fitted with pinch rolls to impress a positive tension on the strip. Sufficient babbitt is removed to give the required total thickness from the underside of the steel back to the top of the bearing surface. The final stage is a stamping and blanking press which cuts the strip into blanks of the right size for the subsequent forming of the half shells.

Photo-Elastic Analysis of Stresses in a Steam Turbine Blade Root (with Discussion. (J. J. Ryan and J. T. Rettaliata, Trans. A.S.M.E., Vol. 62, No. 6, Aug., 1940, pp. 503-511.) (82/35 U.S.A.)

The analysis of the stresses in steam turbine blade roots by photo-elastic methods has particular reference to the determination of the loadings on the multiple steps. In this paper, from a comparison of test and calculated values, the stress concentration factors are obtained for the neck and step sections.

Permanence of the Physical Properties of Plastics (with Discussion). (J. Delmonte, Trans. A.S.M.E., Vol. 62, No. 6, Aug., 1940, pp. 513-524.) (82/36 U.S.A.)

Plastic materials are subject to certain changes in physical properties during their various applications. Particularly significant are the creep and cold-flow phenomena. In the paper a general equation is developed expressing plastic deformation rate as a function of a coefficient of viscous resistance and of a coefficient of internal resistance. Data for laminated phenolics, polyvinyl chloride acetate, methyl methacrylate, polystyrene, and cellulose acetate are compared. Experimental evidence is presented to show that after a sufficient length of time plastic deformation assumes a constant rate, continuing indefinitely. The dual nature of the molecular structure of plastics is emphasised, in which true elastic deformation may occur, as well as a time dependent plastic deformation, even at very low stresses. Further data are presented on the shrinkage of various plastics after exposure to elevated temperatures, and the swelling of these materials after exposure to high humidity or water immersion. Loss in impact strength upon exposure to high temperatures is also disclosed for laminated phenolics.

The Battery-Driven Road Vehicle. (Fletcher, Metropolitan Vickers Gazette, Aug., 1940, pp. 28-33.) (82/37 Great Britain.)

The developments which have led to the successful re-introduction of battery-driven road vehicles are outlined and the author goes on to describe the features of the modern Metrovick vehicle. These include a rigid, lightweight chassis of high strength, a simple and robust drum controller and a motor incorporating heat-resistant insulation. The patented M.-V. parallel series system of battery control, a means of preventing immediate application of full battery voltage whilst yet allowing the rate of acceleration to be controlled and the provision of foolproof features of control are mentioned. A table is included giving comparative operating costs of equivalent petrol and electric vans and graphs of the performance characteristics of Metrovick electric vehicles indicate their suitability for delivery work. Illustrated with two photographs, two graphs and one table. (Abstract supplied by Metropolitan Vickers Research Department.)

A Proposal for Reduction of Polarisation Errors in Loop Direction Finders. (F. E. Terman and J. M. Pettit, Proc. Inst. Rad. Engs., Vol. 28, No. 6, June, 1940, p. 285.) (82/38 U.S.A.)

One of the serious limitations of the radio compass has been the " night effect " error caused by the horizontally polarised component of the sky wave which is picked up by the horizontal elements of the loop. The Adcock antenna overcomes this limitation, but in proportion to size has low pick-up to vertically polarised waves and so is not suitable for most applications.

The remedy proposed in this paper is to employ the conventional multi-turn loop, with all its undesired pick-up of the horizontal component, and then by means of additional horizontal pick-up from an auxiliary antenna to neutralise the unwanted component in the output circuit of the main loop.

The requirements of the system are that the auxiliary antenna provide a voltage which can be coupled into the loop output circuit through a simple network, and which will perform properly for the desired range of wave length, signal azimuth, angle of incidence of the sky wave, etc. The analysis shows that when the earth has a high reflection coefficient a horizontal dipole antenna, mounted on the main loop (and rotating with it) and suitably coupled, is capable of providing complete or nearly complete neutralisation of the horizontal pick-up, with no tuning required other than an initial adjustment.

Radio Direction Finding for Meteorological Balloons at 1.67 Meters. (L. C. Yuan and S. S. Mackeown, Proc. Inst. Rad. Engs., Vol. 28, No. 6, June, 1940, p. 286.) (82/39 U.S.A.)

Different antenna systems were tested for both horizontal and vertical directivity on this wave length at distances of from 7 to 30 miles. The antennas used in these experiments included parabolic, V, double V, Adcock, etc.

Using an Adcock antenna, the azimuth of the in-coming electro-magnetic wave was determined within one half degree accuracy. With a slight modification of the receiving elements to form a horizontal H antenna, the vertical angle of the in-coming wave was also obtained with the same degree of accuracy. One type antenna could be converted into the other type by mechanical means within a few seconds and thus both vertical and horizontal angles could be measured with the same antenna set-up.

With the antenna one and a half wave lengths above the ground and with the ground surface homogeneous in the immediate vicinity of the receiving antenna, the horizontal and vertical direction of the in-coming electro-magnetic wave coincided with that of the transmitter emitting the wave, within the same accuracy of one-half degree. No tests were made at a vertical angle greater than $7\frac{1}{2}$ degrees.

Deviations from the true directions at different locations and at different times were observed. These deviations were primarily caused by irregularities and lack of uniformity in the ground near the receiver.

The receiver used for this experiment is a super-heterodyne specially designed for this purpose using a resistance-coupled intermediate-frequency amplifier. It is very stable in operation and has ample sensitivity.

Reflection Curves and Propagation Characteristics of Radio Waves Along the Earth's Surface. (J. S. McPetrie and A. C. Stickland, J. Inst. Elec. Engs., Vol. 87, No. 524, Aug., 1940, pp. 135-145.) (82/40 Great Britain.)

The paper contains curves from which the reflection coefficient at the earth's surface for radio waves of any state of polarisation can be determined for angles of incidence greater than 80°. It is pointed out that the ray theory, on which the reflection from a reflector is assumed to be equal to the radiation from an image of the transmitting aerial in the reflecting surface is not applicable at grazing incidence unless the heights of the transmitting and receiving aerials are comparable with the wave length. From an analysis given by Norton, however, it is deduced that, when the ray theory does not apply, the field at the receiver is equal in most practical cases to the vector addition of two fields, one of which is given by the ray theory, and the other, which corresponds to the Sommerfeld surface wave, having a magnitude dependent on the electrical properties of the reflector and the distance between transmitter and receiver, but independent of the heights of transmitter and receiver. The ratio of the magnitudes of the surface wave to image fields is much less for horizontally than for vertically polarised waves, so that the ray theory is applicable over a wider range of angles of incidence for horizontally than for vertically polarised waves.

An Experimental Investigation of the Propagation of Radiation Having Wave Lengths of Two and Three Metres. (J. S. McPetrie and J. A. Saxton, J. Inst. Elec. Engs., Vol. 87, No. 524, Aug., 1940, pp. 146-153.) (82/41 Great Britain.)

The paper describes the results of an experimental investigation of the characteristics within optical range of the propagation over land of radiation having wave lengths of 2 and 3 metres. It is shown both theoretically and experimentally that for such conditions the propagation of horizontally and vertically polarised waves is identical over a range of transmitter and receiver heights which are small compared with the distance between transmitter and receiver, but not small compared with the wave length. In these circumstances, for a receiver at height h_R metres the field strength in volts per metre at a distance d metres from a half wave length radiator at a height h_T metres is given by

$$e = \{ 90\sqrt{(Ph_T h_R)} \} / (\lambda d^2)$$

in which P is the power (watts) radiated at a wave length λ (metres). Continuous observations of field strength showed that within optical range of the transmitter the fading was less than ± 3 db.

Radio Direction Finding on Wave Lengths between Two and Three Metres. (R. L. Smith-Rose and H. G. Hopkins, J. Inst. Elec. Engs., Vol. 87, No. 524, Aug., 1940, pp. 154-158.) (82/42 Great Britain.)

This paper describes a preliminary investigation of radio direction finding on wave lengths between 2 m. and 3 m. (100 to 150 mc./s.) with the aid of instruments fitted with rotating aerial systems similar to those used in earlier work in the band 6 m. to 10 m. (30 to 50 mc./s.). The sensitivities of the loop and Adcock direction finders used are such that bearings with a swing of $\pm 5°$ can be obtained with field strengths of 20 and 40 μV per metre respectively. The

reciprocal error of the instruments has been reduced to 1°, and the polarisation error can be kept below 5° for angles of incidence and polarisation to the vertical of 60°, although readjustment of the compensation arrangement is required to maintain this over an appreciable wave band. The two direction finders have been operated at various distances up to 30 miles from an experimental transmitter developing 100 watts on a wave length of 3 m., and the average errors varied from about 10° at one mile to 3.5° at 20 miles with a vertical transmitting aerial. These errors are somewhat larger than the corresponding values found for the longer wave band of 6 m. to 10. (30 to 50 mc./s.). When an attempt was made to use a direction finder inside a wooden hut, the observations were found to be subject to an octantal error of 2° to 5° amplitude, the value increasing as the wave length was reduced. This error was found to be due to reflection effects from the walls of the hut, and experiments made with various wooden boards showed that it depended upon the nature of the wood and direction of the grain. A synthetic material with no grain direction was found to have only a small effect.

Materials for Vacuum Tube Manufacture. (A. J. Monack, Ind. and Eng. Chem. (Ind. Ed.), Vol. 32, No. 8, Aug., 1940, pp. 1,028-1,033.) (82/43 U.S.A.)

The requirements of metals and alloys for cathodes, anodes, and grids are presented, and a brief treatment of thermionic emission in the cases of oxide coated thoriated tungsten, and tungsten filaments is given. Metals and alloys for use in glass metal seals are enumerated. The function of getters is explained in connection with the exhaust process. Types of photo-electric tubes and their uses are discussed. Silicates, sulphides, and tungstates are treated in terms of persistence and colour of luminescence when used for fluorescent screens in cathode ray tubes. Miscellaneous materials and parts are listed, and cleaning of vacuum tube parts is discussed in terms of methods.

LIST OF SELECTED TRANSLATIONS.

NOTE.—Applications for the loan of copies of translations mentioned below should be addressed to the Secretary (R.T.P.), Ministry of Aircraft Production, Thames House, Millbank, S.W.1, and copies will be loaned as far as availability of stocks permits. Suggestions concerning new translations will be considered in relation to general interest and facilities available.

Lists of selected translations have appeared in this publication since September, 1938.

ARMAMENTS AND THEORY OF WARFARE.

TRANSLATION NUMBER AND AUTHOR.		TITLE AND JOURNAL.
1098	Rutkovsky, F. ...	*Bombing Attack on Targets in the Air.* (Aeroplane, U.S.S.R., Vol. 17, No. 5, March, 1940, pp. 19-21.)

AERO AND HYDRODYNAMICS.

1082	Ferrari, C.	*Fields of Motion in Compressible Fluids.* (L'Aerotecnica, Vol. 18, No. 4, April, 1938, pp. 400-411.)
1090	Leybenson, L. S. ...	*Approximate Integration of the Equation of the Boundary Layer according to the Methods of the Heat Conductivity Theory.* (Trans. Joukowski Academy of Military Aeronautics, No. 13, 1935, pp. 38-52.)
1094	Seibert, O.	*Measurement of the Heat Transfer of Wing Profiles.* (Jahrbuch der deutschen L.F.F., Vol. 2, 1938, pp. 224-244.)
1099	Huchmann, A. A. ...	*Similarity between Velocity and Temperature Fields in Gaseous Flow.* (Trans. All-Union Conference on High Speed Aircraft, Moscow, 1936, pp. 119-126.)

AIRSCREWS.

1085	Schmidt, K. A. ...	*Basic Problem of Variable Pitch Propeller Design. (With special reference to the principal German designs.)* (Luftwissen, Vol. 6, No. 10, Oct., 1939, pp. 267-273.)
1089	Betz, A.	*Concerning an Extension of the Propeller Slipstream Theory.* (Z.F.M., Vol. 11, 1920, pp. 105-110.)
1093	Grandinetti, A. ...	*The Arrangement of Airscrews in Tandem in Twin-Engined Aeroplanes and the Efficiency of the Group.* (Ingegneria, Vol. 6, No. 5, May, 1927, pp. 172-177.)

ENGINES AND ACCESSORIES.

1038	Schmidt, E.... ...	*Supercharging Tests on Pre-Combustion Chamber Diesel Engines.* (Jahrbuch der deutschen L.F.F., Vol. 2, 1938, pp. 48-52.)

TRANSLATION NUMBER AND AUTHOR.		TITLE AND JOURNAL.
1083	Cornelius, A. ...	*Mathematical Investigation and Design of High Speed Crankshafts.* (A.T.Z., Vol. 42, No. 14, 25/7/39, pp. 385-393.)
1084	Bollenrath, F. ... Cornelius, H. ... Bungardt, W. ...	*Investigation on the Suitability of Heat-Resistant Materials for Combustion Engines.* (L.F.F., Vol. 15, No. 9, 10/9/38, pp. 468-480; No. 10/11, 10/10/38, pp. 505-510.)
1086	Lutz, O.	*Resonance Oscillations in the Induction and Exhaust Pipes of In-Line Engines. Report No. 1. The Processes in Unbranched Pipes, excited at a Number of Positions.* (L.F.F., Vol. 16, No. 3, 20/3/39, pp. 139-147.)
1087	Lutz, O.	*Resonance Oscillations in the Induction and Exhaust Pipes of In-Line Engines. Part 2. The Processes in Branched Pipes.* (L.F.F., Vol. 16, No. 7, 20/7/39, pp. 384-90.)
1088	Lutz, O.	*Resonance Oscillations in the Induction and Exhaust Pipes of In-Line Engines. Part 3. The Conditions of Excitation in the Induction Process of Four-Stroke Engines.* (L.F.F., Vol. 17, No. 4, 20/4/40, pp. 123-8.)
1092	Fischer, G.	*Tests on Light Alloy Bearing Materials in the D.V.L. Bearing Testing Machine.* (L.F.F., Vol. 16, No. 1, 10/1/39, pp. 1-13.)
1095	Franz, A.	*Problems Associated with the Measuring Technique in Experiments with Superchargers.* (Jahrbuch der deutschen L.F.F., Vol. 2, 1938, pp. 215-18.)
1100	Nikolaenko, V. G. ...	*Design of a Cooling System for Aero Engines, taking into Consideration the Compressibility of the Air.* (Aeron. Eng., U.S.S.R., Vol. 14, No. 2, Feb., 1940, pp. 52-66.)
		INSTRUMENTS.
1091	Burger, K.	*Precision Measuring Instruments Exhibited at the Leipzig Spring Fair, 1939.* (Maschinenbau, Vol. 18, No. 9/10, May, 1939, pp. 227-230.)
1096	Reussner, E. A. ...	*Discussions on the German Official Regulations Governing Aircraft Construction (B.V.F.). Part 5/1, Electrical Equipment.* (Luftwissen, Vol. 7, No. 1, Jan., 1940, pp. 13-14.)
1097	Yukelise, E. ... Bogatirev, L. ...	*Simplest Methods for Determining Direction of Flight without a Compass.* (Aeroplane, U.S.S.R., Vol. 16, No. 22, Nov., 1939, p. 31.)

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(Prepared by R.T.P.)

No. 83. October, 1940.

Application of the Similarity Theory of Turbulence to the Flow Through a Straight Pipe of Annular Cross-Section. (S. Tomotika, K. Tamada and Y. Saitō, Aer. Res. Inst., Tokyo, No. 188, March, 1940.) (83/1 Japan.)

The distribution of mean velocity, U, in turbulent flow of a fluid flowing under pressure through a straight pipe of annular cross-section is calculated on the basis of the similarity theory of turbulence, assuming that the mean motion is steady and symmetrical about the axis of the pipe. Both the vorticity transport and the momentum transport theories are employed. Remembering that dU/dr changes its sign at the position of maximum mean velocity, the annular region is divided, as in our previous paper, into two regions, *i.e.*, the inner and the outer regions, and these two regions are treated separately.

The calculated results are compared with Mikrjukov's experimental results, of which a brief description has been given in our previous paper.

It is found that the vorticity transport theory gives results in fairly good agreement with observation over nearly the whole range in both the inner and outer regions except near the walls. The results obtained by the momentum transport theory, on the other hand, are in very poor agreement with experiment.

Note on the Application of the Momentum Transport Theory to the Turbulent Flow Through a Straight Pipe of Annular Cross-Section. (S. Tomotika and H. Umemoto, Aer. Res. Inst., Tokyo, No. 189, May, 1940.) (83/2 Japan.)

In the present paper, the distribution of mean velocity in turbulent flow of a fluid flowing under pressure through a straight pipe of annular cross-section is re-calculated on the basis of the momentum transport theory of turbulent motion. The treatment of the problem in the present paper is more appropriate and more exact than that given in our previous paper, where the flow through an annular pipe was treated as if it were two-dimensional.

As in the previous paper, the annular region is divided into the inner and outer regions, and it is assumed that in the inner region the mixing length is proportional to the distance from the inner wall of the annular pipe, while in the outer region it is proportional to the distance from the outer wall.

The calculated results are compared with Mikrjukov's experimental results and also with the theoretical results obtained in the previous paper on the basis of the modified vorticity transport theory.

It is found that the results obtained on the modified vorticity transport theory are in better agreement with observation than those calculated on the momentum transport theory and the approximate results previously obtained by assuming two-dimensional flow are thus confirmed.

Application of the Vorticity Transport Theory to the Turbulent Flow Through a Straight Pipe of Annular Cross-Section. (S. Tomotika and K. Tamada, Aer. Res. Inst., Tokyo, No. 190, May, 1940.) (83/3 Japan.)

In the present paper, the distribution of mean velocity in turbulent flow of an incompressible fluid flowing under pressure through a straight pipe of annular cross-section is calculated by applying the vorticity transport theory with symmetrical turbulence, on the assumption that both the mean motion and the turbulent motion are symmetrical about the axis of the pipe and that the pressure gradient along the pipe is constant and also the mean motion is steady.

As in our previous papers, the calculated velocity distributions are compared with Mikrjukov's observation. It is thus found that the vorticity transport theory with symmetrical turbulence gives results in somewhat better agreement with observation than does the modified vorticity transport theory employed in a previous paper.

In this connection it will be worth noticing that both vorticity transport theories are in better agreement with experiment than the momentum transport theory.

Counter Rotating Airscrews. (H. M. McCoy, Inter. Avia., No. 721, 6/8/40, pp. 1-4.) (83/4 U.S.A.)

Counter rotating airscrews have so far been utilised on fixed wing machines in three different versions:—

1. Twin-engined aircraft with tractor airscrews rotating in opposite directions.
2. Combination of pusher and tractor airscrews at opposite ends of the engine power plant usually two engines placed back to back—so-called open tandem spacing.
3. Two oppositely rotating airscrews placed immediately one behind the other on concentric shafts (close tandem).

A machine fitted with airscrews rotating in opposite directions is freed from torque reaction and in addition there is generally an improvement in longitudinal stability.* At high flying speeds, moreover, the close tandem arrangement may produce an appreciable increase in propulsive efficiency by reducing the rotary slipstream losses. As is well known, such losses only become appreciable at high blade angles (*i.e.*, high flying speeds) and below 350 m.p.h. (*i.e.*, for blade angles $< 45°$) the predominant slipstream losses are axial.

Tests on a Curtiss P-36 fighter fitted with close tandem airscrews showed a marked improvement in control. Improvement in performance was not shown nor expected, since the flight speeds were too low. A remarkable freedom from engine vibrations was specially noted. It is confidently stated that higher flight speeds in the future will lead to a more general introduction of the close tandem arrangement. Some of the further advantages claimed are listed below:—

1. Reduction of span of fast single-engined fighters (lighter wing and greater structural efficiency).
2. Decreased turbulence in slipstream delays separation of boundary layer.
3. Vertical fin need not be off-set.

Disadvantages are weight and cost of gearing.

Boeing Strato Chamber. (Inter. Avia., No. 722, 12/8/40, p. 10.) (83/5 U.S.A.)

The "Stratoliners" of T.W.A. and P.A.A. have collected experience of flights at altitudes up to 15,000 ft. and 20,000 ft., carried out with supercharged cabins simulating flying altitudes equivalent to 8,000 ft. and 12,000 ft., respectively. There was found to be a need for the creation of testing facilities on the ground of such aircraft components as windows, doors, etc., under the conditions encountered in altitude flight. The Boeing "Strato-Chamber" consists of a three-

* See M.A.P. translation No. 853.

ton tank 12 ft. long by 5½ ft. in diameter, fitted with pressure-tight doors at each end and divided into two compartments which are inter-connected. In the first smaller compartment the air is refrigerated by dry ice and its pressure reduced in order to reproduce the atmosphere prevailing at high altitudes; in the other the atmosphere maintained in the supercharged cabin is reproduced. This test chamber, which to-day permits tests to be carried out at simulated altitudes of up to 40,000 ft., may be used also for physiological experiments; by the addition of stronger pumps the present "level" could be increased for research purposes to about 60,000 ft.

Civil Aviation Record in the U.S.A. (Inter. Avia., No. 722, 12/8/40, p. 18.) (83/6 U.S.A.)

In the first six months of the year, the air lines of the United States flew a total of 553,077,175 revenue passenger miles, compared with 278,353,321 miles in the corresponding period of 1939. June was the peak month for all times, with 101,172,222 revenue passenger miles, compared with 90,662,538 miles in May and 63,576,325 miles in June, 1939. This increase is due, no doubt, partly to the boom created in the U.S.A. by the war in Europe, but also by the excellent safety record of the U.S. domestic air lines. The C.A.B. has announced that up to August 1st the domestic air lines of the United States had flown 1,249,594,263 passenger miles without injury to either passengers or crew in a period of over 16 months since the last fatal accident in scheduled service on March 26th, 1939. During this period, 3,158,159 passengers have been carried. Another expression of confidence in the safety of the air lines is seen in the fact that the Equitable Life Assurance Society, of New York, has removed all restrictions and extra premiums on policies of persons flying as paying passengers on scheduled aeroplanes operated by the commercial air lines within the United States. Since 1935 the Equitable Life Assurance has paid $109,000 on twelve claims resulting from deaths within the United States on the regular air routes, the last of which was paid at the beginning of 1939.

Research Methods of United Air Lines. (J. P. Auwerter, Aviation, Vol. 39, No. 9, Sept., 1940, pp. 30-31, 100-114.) (83.8 U.S.A.)

The American Transport Company, known as United Air Lines, has spent about $400,000 on technical research under four main headings: Communications, engineering, medical and future developments.

Communications is dealt with by a separate department, and as its name implies is concerned mainly with radio. A well equipped laboratory enables special radio equipment to be constructed and subsequently tested under working conditions. High altitude and low temperature chambers enable the effects of atmospheric conditions to be investigated and the effect of vibration and shock are studied on suitable benches before flight tests are carried out on a special "laboratory" aircraft.

The department also acts as advisor to the company when purchasing standard equipment and all the troubles experienced in practice are referred to it.

Engineering Research deals mainly with passenger comfort, but any troubles with mechanical equipment, including engines and accessories, are also notified to this department.

A well equipped *Medical Laboratory* puts the whole of the flying staff at least once a year through a series of special tests which complement the routine health tests carried out at the local airports. Finally, problems concerning the *Future of Air Travel* are dealt with by a separate department, which so far has concentrated on questions of passenger comfort at high altitudes.

The basis of the whole research organisation is a pooling of experience, and before any new work is undertaken, the greatest possible care is taken to ensure that all published information on the subject has been made available to the men in charge.

The Size of an Aircraft Landing Field. (K. N. E. Bradfield, Engineer, Vol. 170, No. 4,422, 11/10/40, pp. 230-231.) (83/9 Australia.)

The minimum dimensions required for various classes of airports as laid down by the Governments of Australia, Gt. Britain and U.S.A. are given in the following table. The figures apply to sea level in positions where winds stronger than 5 m.p.h. are liable to occur from all points of the compass.

	Australia, 1940 Minimum dimensions	Great Britain, 1938 Minimum dimensions	U.S.A., 1939 Proposed minimum dimensions
First class	"Run" in one direction 4500 ft. In all other directions 3000 ft. Minimum angle of approach 1 in 30.	One landing strip 3900 ft. long and 1200 ft. wide. Three others 3000 ft. long and 600 ft. wide. Minimum angle of approach 1 in 15.	Four landing strips, each 4500 ft. long and 500 ft. wide. Minimum angle of approach 1 in 20.
Second class	"Run" in one direction 3600 ft. In all other directions 2400 ft. Minimum angle of approach 1 in 20.	Landing strips 2400 ft. long and 600 ft. wide for all wind directions. Minimum angle of approach 1 in 15.	Four landing strips, each 3500 ft. long and 500 ft. wide. Minimum angle of approach 1 in 20.
Third class	"Run" in one direction 2400 ft. In all other directions 1800 ft. Minimum angle of approach 1 in 15.	Landing strips 2100 ft. long and 600 ft. wide for all wind directions. Minimum angle of approach 1 in 15.	Four landing strips, each 2500 ft. long and 500 ft. wide. Minimum angle of approach 1 in 20.
Fourth class	"Run" in one direction 1800 ft. In all other directions 1320 ft. Minimum angle of approach 1 in 15.	Landing strips 1800 ft. long and 600 ft. wide for all wind directions. Minimum angle of approach 1 in 15.	Four landing strips, each 1500 ft. long and 300 ft. wide. Minimum angle of approach 1 in 20.

The actual requirements for take-off are usually less than 1000 feet, but they may be considerably increased by high temperature or soft ground. Thus a rise in ground temperature from 60°F. to 110°F. increases the take-off by about 10 per cent., whilst a change over from a paved runway to a grass field will increase the necessary run by about 40 per cent.

Even so the figures given in the table for prepared surfaces appear very large. The figures quoted are, however, intended to give ample margin for safety, especially in the case of one engine failing during the take-off of twin-engined aircraft. Although such aircraft can generally maintain level flight with only one engine, the rate of climb is seriously reduced. This has led the C.A.A. (U.S.A.) to suggest the following two safety requirements:—

1. The airport dimensions should be such that in the case of one engine failing after one half of the runway has been covered (whether the machine is by that time still on the ground or flying) it must be possible to continue the flight in a straight line on the remaining engine and clear all obstacles which lie ahead.

2. The runway length should be such that the aircraft can be brought to flying speed with one engine dead and if at this critical moment the remaining engine should fail, it should be possible to land the aircraft and bring it to rest without over-running the end of the runway.

The figures in the table have been calculated bearing in mind these recommendations.

Manœuvrability and Control Surface Strength Criteria for Large Aeroplanes. (H. B. Dickinson, J. Aeron. Sci., Vol. 7, No. 11, Sept., 1940, pp. 469-477.) (83/10 U.S.A.)

A method has been developed which makes possible the determination of the horizontal tail strength required by the basic flight envelope which governs the strength of the wings. The method involves only the use of simple wind-tunnel data. It is shown that the manœuvring tail loads can be obtained without reference to the effect of the trimming tab. The controllability in pitch should be sufficient to subject the aeroplane to the flight envelope load factor at any speed.

The controllability criterion for the vertical tail is that the critical control speed with flaps in the landing position should not exceed the landing speed, and with the flaps in the take-off position should not exceed take-off speed. The strength of the vertical tail should be based upon the use of the tab angle for trim with engines inoperative, together with a manœuvring pedal force.

It is suggested that the aeroplane should not run out of aileron control at a higher speed than it runs out of rudder control. Rational load criteria for the ailerons have not been developed.

It must be realised that the methods presented are in a crude stage of development, and that much refinement will be necessary before they can be regarded as completely satisfactory. It is felt, however, that the general principles discussed will afford reasonable bases for manœuvrability and manœuvring load criteria.

Effects of Propeller Slipstream and Tail Position on the Vibration Characteristics of the Lockheed Lodestar. (R. L. Thoren, C. L. Johnson, J. Aeron. Sci., Vol. 7, No. 10, Aug., 1940, pp. 419-421.) (83/11 U.S.A.)

Flight tests of the Lockheed Lodestar revealed excessive vibration in the cabin. Exhaustive tests proved beyond a doubt that the source of the vibration was aerodynamic in nature, specifically, an interference condition between the propeller slipstream and the stabiliser. Surveys of the flow at the tail indicated that at cruising engine speeds, in level flight, the slipstream just bordered on the horizontal stabiliser and created a vibration in the tail unit which was transmitted into the fuselage. Various changes were made in the aeroplane in an

attempt to remedy this condition and finally, by elevating the tail unit one foot above its previous position, the vibration was entirely eliminated.

Boundary Layer and Wake Survey Measurements in Flight and in the Wind Tunnel. (L. B. Rumph and R. Schairer, J. Aeron. Sci., Vol. 7, No. 10, Aug., 1940, pp. 425-433.) (83/12 U.S.A.)

The results of this investigation show that the apparatus developed for measuring wing section drags in flight is practical and is amenable to quick adaptation to a full scale aeroplane. The boundary layer surveying equipment was successful as far as its mechanical operation was concerned, but caution should always be taken to keep the surveying plane outside the propeller slipstream. A technique has been developed so that rapid measurements can be made in order to reduce the expanse of flight testing. The real value of the tests will be enhanced when additional measurements may be made with smoother surfaces in flight and rougher surfaces in the wind tunnel.

Using Karman's skin friction law for extrapolation to the same Re, the wind-tunnel test (very smooth model) gave a profile drag coefficient which was appreciably smaller than that given in flight. The difference is of the order of 10 per cent. for the Douglas DC4 and 50 per cent. for the Lockheed 14.

The wind-tunnel measurements furnish further evidence to corroborate contentions in other papers that transition does not occur at a particular transition Reynolds Number, R_x. The correlation between transition and drag measurements in the wind tunnel is excellent. The detrimental effect of rivets on drag is very evident from the flight wake survey results.

Frequency and Vibration Problems of Rotors (Rotary Wing Aircraft). (R. H. Prewitt and R. A. Wagner, J. Aeron. Sci., Vol. 7, No. 10, Aug., 1940, pp. 444-450.) (83/13 U.S.A.)

(1) With normal vertical pin locations, and without additional centering springs, the natural pendular frequency of the blade about the vertical pin is from 1/3 to 1/5 the rotor speed. The theoretical value of frequency is usually reduced because of the lack of fixity of the hub. This reduction in pendular frequency of the blade amounted to 30 per cent. in one case.

(2) With additional specialised centering means the natural pendular frequency of rotor blades may be made to vary with amplitude of oscillation.

(3) The natural flapping frequency of a rotor blade with the flapping axis perpendicular to the blade, and located on the axis of rotation, neglecting damping is equal to the rotor r.p.m.

(*a*) Moving the flapping axis outboard increases that natural frequency in a normal design approximately 2½ per cent.

(*b*) Average coning of the blade reduces the basic natural frequency in a normal design approximately 3 per cent.

(*c*) Damping reduces the basic natural frequency approximately 15 per cent. with the flapping axis perpendicular to the blade.

(*d*) Cocking the horizontal hinge toward the leading edge of the blade has the effect of increasing the value of the damped natural frequency with increases in the angle of cocking.

(4) The natural bending frequency in the plane of flapping depends so much upon the structure of the blade that no one value can be given for this term. The natural bending frequency in the plane of flapping for a plywood covered blade having a chord of 1 ft., a radius of 20 ft. and a 17 per cent. thickness ratio, at 200 r.p.m. of the rotor, is approximately 2¾ times the rotor speed.

(5) A more complete analysis of all of the possible combinations of resonance should be done; however, it is believed that the mathematical and empirical analysis given by the author will assist those interested in rotor aircraft design to eliminate resonance problems.

Relative Consumption of Normal and Supercharged Four-Stroke Diesel Engines fitted with Direct and Exhaust Driven Blowers Respectively. (P. Jackson, Engineering, Vol. 150, No. 3,898, 27/9/40, p. 256.) (83/14 Great Britain.)

The specific fuel consumption curves of the same 6-cylinder engine (except for valve overlap) under various conditions of supercharge are summarised in the following table.

The rating of the normal engine is 340 b.h.p. at 750 r.p.m.

B.M.E.P. lb./sq. in.	lb/B.H.P. hour. Normal.	Supercharged. Mechanical.	Exhaust driven.
20	.59	—[2]	.50
30	.49	—	.44
40	.44	—	.41
50	.415	—	.39
60	.39	—	.38
70	.385	—	.37
80	.38	—	.365
87	.38[1]	.40	.365
90	.385	.40	.365
95	.390	.40	.365
100	—	.40	.370
103	—	.405[3]	.370
110	—	.410	.375
120	—	—	.385[4]
130	—	—	.395

[1] Normal full load.
[2] Mechanical blower disconnected.
[3] Mechanical blower net full load.
[4] Exhaust driven blower full load.

From these figures it appears that the exhaust driven blower (with scavenging) gives an appreciable reduction in specific fuel consumption over the mechanically operated blower. Moreover, this benefit is maintained at part load, when the mechanical blower must be disconnected. On the other hand, the cost of the latter is only about half that of the exhaust driven job and the installation is very much simpler.

Aero Engines and Their Laboratory Testing under Flight Conditions. (L. Massuger, J. Aeron. Sci., Vol. 7, No. 11, Sept., 1940, pp. 481-482; Digest.) (83/15 France.)

The author is a member of a well-known French engine firm (Hispano) and some of his conclusions are given below:—

1. *Engine vibration dampers* of the pendulum type are very efficient. The total weight of such dampers as fitted to the 1200 h.p. Hispano engine is only 6 lbs. and by their means the harmonic of the order $2\frac{1}{2}$ of the gas pressure torque is completely eliminated.

2. Turbo compressors have been successfully employed on Diesel engines, mainly because this type of engine lends itself to scavenging. In order to make scavenging possible on aircraft engines, the carburettor must be replaced by a petrol injection system. Quite apart from this possibility, the petrol injection system has many other advantages which make it attractive for aircraft engines.

3. Co-axial, oppositely rotating propellers, balance torque reaction and eliminate the swirl of the slipstream. The efficiency of such a system is always 2-5 per cent. greater than that of the equivalent 4-bladed propeller.

4. Reference is made to the Hispano Suiza high altitude chamber for testing aero engines up to 1,200 h.p. at altitudes up to 10,000 m.

The refrigerating plant permits temperatures as low as $-50°C.$ for the intake air. The exhaust gases, after being cooled and washed, are mechanically extracted and discharged into the atmosphere.

The main exhaustor for the intake is of the 2-stage type, the first stage sufficing for altitudes up to 5000 m.

The firm also possess a high speed wind tunnel (210 m.p.h.) in which the lift, drag and rolling moments of engine nacelles with a power output up to 2,000 h.p. can be measured.

Approximate Formulas for Piston Travel in Radial Engines (*see also Atti di Guidonia, No.* 4, 1/4/39). (H. W. Sibert, J. Aeron. Sci., Vol. 7, No. 10, Aug., 1940, pp. 434-437.) (83/16 U.S.A.)

A simplified equation involving two Fourier series is given for the piston travel when the angular spacing of knuckle pin holes equals the angular spacing of the cylinder axes. Tables are given for determining the coefficients and phase angles of these two Fourier series. Formulas and tables are also given for finding the error due to using only the first two terms of these series. A simplified approximate formula for piston travel is also given, from which formulas for maximum and minimum piston travel are derived.

The Static Coefficient of Lubricated Surfaces. (A. Fogg and S. A. Hunwicks, Engineer, Vol. 170, No. 4,420, 27/9/40, pp. 206-207, and No. 4,421, 4/10/40, pp. 214-216.) (83-17 Great Britain.)

When determining the coefficient of static friction with machines of the Deely type, everything depends on the method of cleaning adopted for preparing the standard surface. The author experimented with hard steel surfaces which were cleaned with abrasives. Under these conditions, which correspond to minimum oiliness, the coefficient of friction was of the order of .58 and represents an upper limit. The following table gives the friction coefficient in the presence of various lubricants.

Lubricant.	Coefficient of friction.
Benzene	.48
Alcohol	.43
Trichlorethylene	.33
Glycerin	.20
B.P. paraffin	.18
Plain lubricating oil	.15
Synthetic lubricating oil	.14
Graphited lubricating oil	.13
Extreme pressure lubricants	.10
Oleic acid	.08

It is interesting to note that the coefficient of friction obtained in this manner is only very slightly affected by temperature over the range $20°C.$-$100°C.$ In several instances a rise in temperature increased the friction. As is well known, the addition of oleic acid or rape oil to mineral lubricating oil improves the oiliness. It is generally held that the full benefit is obtained with relatively small additions. The authors' experiments, however, show that, although the first small additions produce a relatively greater effect, the coefficient of static friction is reduced progressively with addition, the lowest value being obtained with 100 per cent. rape or oleic acid.

The work is being extended to cover other combinations of metal.

The Oiliness of Lubricating Oils. (Engineer, Vol. 170, No. 4,420, 27/9/40, pp. 202-203.) (83/18 Great Britain.)

It is well known that the friction of a fully lubricated bearing depends only on the rate of shear of the oil film and can therefore be calculated from the viscosity characteristics of the oil as determined in the laboratory. Provided the film exceeds a minimum thickness, the nature of the bearing surfaces does not affect

the resultant friction. If, however, the film becomes very thin, the friction can no longer be calculated with the help of hydrodynamic theory and the type of bearing metals employed also affects the result. The particular characteristic of the lubricant causing differences in the behaviour of bearings working under such conditions is designated as " oiliness " and it is assumed that this factor can be measured by noting the reduction in the coefficient of static friction under controlled conditions in the presence of the particular lubricant. It appears that two perfectly " clean " steel surfaces have a coefficient of static friction of the order of 0.58. In the presence of oleic acid, this is reduced to 0.08, and represents maximum " oiliness." Other lubricants fall in line between these limits and it is stated that the order of merit obtained in this manner is in general agreement with practical experience as to the behaviour of the lubricant in " oil starved " bearings.

(Considerably more experimental work with different metals appears to be required before such a conclusion can be generally accepted.)

Castigliano's Principle of Minimum Strain-Energy and the Conditions of Compatibility for Strain. (R. V. Southwell, Phil. Mag., Vol. 30, No. 200, Sept., 1940, pp. 252-258.) (83/19 Great Britain.)

In an earlier paper, of the six equations of compatibility three were deduced with the use of Maxwell's stress functions, the other three with the use of those of Morera, appeal being made in each instance to Castigliano's principle of minimum total strain energy. A paradox is thus presented, in that it would appear that three of the six equations are redundant.

This paradox is examined in the present paper. It is shown that all six equations are in fact necessary conditions of compatibility, and that the stress functions either of Maxwell or Morera do in fact constitute the most general solution of the stress equations of equilibrium. The paradox is resolved by showing that more might have been proved in the earlier paper; when account is taken of the restrictions imposed by the conditions of equilibrium at the boundary, all six of the equations of compatibility can be deduced as a consequent of Castigliano's principle.

New Covering for the Wing Unit of Aircraft. (L'Ala d'Italia, 16-30/9/40, p. 51.) (83/21 Italy.)

The German aeronautical experimental centre has patented a new process for the covering of wing surfaces. This covering which is perfectly water and airtight consists of a metal fabric between two layers of compressed synthetic resin. For example, using a metal fabric with a weave of 50 to 120 meshes per sq. cm., spun with a 0.12 mm. wire, a covering is obtained with a resistance of 2,000 to 3,000 kg. per metre, for a unit weight of 600 gm. and thickness of not more than 0.25 mm.

Corrosion of Metals Used in Aircraft. (W. Mutchler, Bur. Stan. J. Res., Vol. 25, No. 1, July, 1940, pp. 75-82.) (83/20 U.S.A.)

Investigations of the corrosion of metals used in aircraft have been in progress at the National Bureau of Standards since 1925. The present paper reviews the work that has been done and summarises the more important results.

1. Corrosion of aluminium alloys of the duralumin type is of two distinct types: surface pitting and intercrystalline attack. The former is reduced by keeping the iron and copper content low (at a small sacrifice of strength) whilst intercrystalline corrosion can be entirely avoided by suitable heat treatment.

2. Anodic coatings used in conjunction with good grades of aluminium pigmented varnishes form the best protection under marine conditions.

3. With increased purity of constituents, the corrosion resistance of Mg alloys has improved markedly (intercrystalline corrosion does not occur in magnesium rich alloys).

4. The surface coatings for Mg alloys so far developed are not so efficient as the anodic coatings of Al alloys, but they serve a useful purpose by improving the adherence of paints.

5. Stainless steels containing molybdenum proved more resistant to attack than did those containing titanium or columbium. An alloy containing 16 per cent. Cr and 1 per cent. Ni was more susceptible to corrosion than any of the others.

6. On both Al rich and Mg rich alloys, gas welds were very resistant to corrosion.

7. The ratio of the areas of dissimilar metals in contact often proves a determining factor in corrosion. The insertion of appropriate insulators between the dissimilar surfaces appears to give promising results.

A bibliography of 18 references is given.

Permanent Magnets. (J. F. Kayser, Engineer, Vol. 170, No. 4,419, 20/9/40, p. 183.) (83/22 Great Britain.)

Since 1918 the permanent magnet industry has undergone two major developments: the introduction of cobalt magnet steels in 1923 and the advent of nickel-iron-aluminium permanent magnet alloys in 1933. Recently a further outstanding improvement has been recorded. It appears that if certain alloys containing Co, Ni, Al and Fe are cooled from a high temperature in the presence of a strong magnetic field $(BH)_{max}$, values of the order of 5×10^6 can be obtained, which represents a three to fourfold advance over best previous values. At the same time the remanence of the new steels is of the order of 12,000 and the coercive force in the vicinity of 600.

The advent of this new steel will have a profound effect upon small apparatus hitherto fitted with electro magnets.

Wear Phenomena in Lubricated Metal Surfaces. (A. S. T. Thomson, Engineer, Vol. 170, No. 4,420, 27/9/40, pp. 200-201.) (83/23 Great Britain.)

Experiments were carried out on the wear of brass rubbing on steel using a modified form of the Timken wear testing machine. A hardened steel cylinder (outer race of a Timken bearing) is rotated at a constant speed (650 r.p.m.), the axis of the cylinder being horizontal and the lower rim just dipping into an oil bath kept at 140°F. A square brass block is pressed against the highest point of this cylinder with a known load, which during the running in process corresponds to 200 lb. per sq. in. After about five minutes, a concave matting surface is formed and the tests proper can be started. The load on the brass block is increased in steps, each step lasting 2½ minutes, the wear being measured every half minute by means of a gauge incorporated in the load linkage, the actual approach of the block to the cylinder being indicated on a dial. Comparative tests were carried out with three lubricants:—

(*a*) Standard mineral oil.
(*b*) Standard mineral oil + 15 per cent. oleic acid.
(*c*) Standard mineral oil + 1 per cent. Oildag (" colloidal graphite ").

In each case the shapes of the rate of wear/load curves were similar, exhibiting the following characteristics:—

(1) A linear increase in rate of wear with load up to a certain critical pressure.
(2) A subsequent range of loads over which the wear was very small and independent of load.
(3) A further linear increase with load when the latter exceeded a second critical value.

According to the author, phase (1) corresponds to pure abrasion accompanied by a progressive rise in surface temperature of the brass. This finally leads to the melting of surface irregularities and the re-establishment of an oil film (phase 2). The subsequent phase (3) corresponds to the destruction of this film as the load is increased beyond the second critical value. Although all the three

oils tested exhibit these three phases the second critical pressure in the presence of oleic acid is almost double that for the pure or graphited mineral oil (5,400 against 3,000 lb. per sq. in.).

Development in Cutting Tools. (Engineer, Vol. 170, No. 4,420, 27/9/40, p. 201.) (83/24 Great Britain.)

A new grade 80 Stellite has recently been introduced. In the main it has the same general characteristics as grade 40, including ease of grinding, but the difference in its composition enables it to enter fields in which Stellite has previously not been used. It is stated that grade 80 has met with success in the machining of the higher tensile steels, such as are used in the automobile industry.

The same general conditions must be maintained as in the case of grade 40 Stellite, namely, fixtures and tool holders must be as rigid as possible, with the minimum of overhang. The more efficient a machine tool unit is, the better will be the result obtained. Grade 80 Stellite is not supplied as bar stock, but only in the form of finished tool bits, tipped tools, milling cutter blades and special formed tools, both rectangular and circular in shape. The latter is a recent development and in this particular direction, it is claimed, presents a marked advantage in that it is not economical to manufacture the circular formed tool from tungsten carbide. Results have, it is stated, proved that grade 80 Stellite will give a 6 to 1 advantage in life per grind over high speed steel.

Stellite grade 80 is also used in the form of taper and parallel, hand and machine reamers when used on the lighter alloys of the duralumin group. In such cases the cutting portions of the reamer only are made from Stellite, and the teeth are ground straight into the Stellite. On account of its inherent hardness no heat treatment is required.

Adhesion of White Metal Linings in Bearings. Engineering, Vol. 150, No. 3,898, 27/9/40, p. 250.) (83/25 Great Britain.)

The first essential for good adhesion is that the shell must be given a complete and continuous coating of tin before the white metal lining is poured. It is pointed out in this connection, however, that cast iron and certain alloy steels are difficult to tin, steels containing more than 0.25 per cent. of nickel or more than 0.6 per cent. of manganese being particularly troublesome. The most dependable method in such difficult cases, it has been found, is to copper-plate the shell before tinning. Degreasing should follow as soon as possible on the turning of the shell.

While copper, bronze, brass or mild steel shells may be tinned relatively easily, it is pointed out that the degreasing treatment should be conducted in as thorough a manner as with cast iron or alloy steel shells. They are then pickled to provide a reactive surface. The temperature of the tinning bath, in the case of the copper and copper alloy shells, should be at a maximum of 260 deg. C., in order to avoid the formation of excessive amounts of inter-metallic alloy. The time of immersion should be up to two minutes. For mild steel shells, the tin bath should be at a temperature of 400 deg. C.

Machining with Single Point Tools. (M. Kronenberg, Engineering, Vol. 150, No. 3,898, 27/9/40, pp. 259-260.) (83/26 U.S.A.)

The author investigates cutting speed as a function of

(1) Tool life.

(2) Depth of cut and feed per revolution.

Cutting force is expressed as a function of chip cross sectional area and cutting pressure as a function of depth of cut and feed.

If P_t = h.p. at cutting edge,

V = cutting speed in feet/minute,

F = cutting force in lb.,

A = chip cross sectional area in sq. in.,

we have

$$V = (33{,}000 \times P_t)/F.$$

The author expresses F in terms of A by means of the equation

$$F = C_p \times A^r$$

where C_p and r are material constants. Using a logarithmic diagram, it is thus possible to draw a series of constant h.p. lines connecting V and A (or F). An alternative expression for V for constant tool life is given as

$$V = C_v \times A^{-s}$$

where C_v = constant depending on material, tool, tool life and cutting fluid.
s = a material constant.

Using this equation, a second series of lines can be plotted, connecting V and A (or F) along which the tool life is constant.

An increase in V produces an increase in tool h.p. and a reduction in tool life. The two sets of curves, however, cross at an angle, the lines of constant tool life making a smaller angle with the A axis (abscissa).

From these diagrams the author draws a number of conclusions, of which the main are summarised below. It is assumed that the original adjustment is normal.

(1) Increasing cutting speed at constant tool life leads to a considerable reduction in volume of material removed per minute and is thus unproductive, and the machine is not used to full capacity.

(2) Decreasing cutting speed at constant tool life overloads the machine.

(3) Increase in cutting speed at constant tool h.p. causes a rapid diminution in normal tool life and necessitates the use of special tools (cemented carbide). There is a small reduction in rate of removal of material, but the considerable reduction in cutting force is an advantage (less deflection, greater accuracy, smoother finish).

(4) Decrease in cutting speed at constant tool h.p. increases tool life and rate of removal of material. The disadvantage is the increase in tool pressure.

The Normal Modes of Vibrations of Beams having Non-collinear Elastic and Mass Axes (e.g., Hollow U Shape). (C. F. Garland, J. Appl. Mech., Vol. 7, No. 3, Sept., 1940, pp. 97-105.) (83/28 U.S.A.)

This analysis deals with vibration characteristics of cantilever beams in which the longitudinal axis, passing through the mass centres of the elementary sections, is not collinear with the longitudinal axis about which the beam tends to twist under the influence of an applied torsional couple. Expressions are derived from which the natural frequencies and normal modes of vibration of such a beam can be determined. The Rayleigh-Ritz method is employed to determine the frequencies and amplitude ratios. Following the development of the general expressions, more specific equations are derived which express the natural frequencies and relative amplitudes of motion in each of two normal modes of vibration.

The theoretical relationships of the several physical properties of the beam to the natural frequencies of vibration are shown graphically. Finally, a numerical example is presented for a particular beam, and the computed natural frequencies and normal modes are compared with those determined experimentally; the agreement is very satisfactory.

Applications of X-Ray Technique to Industrial Laboratory Problems. (H. P. Rooksby, G.E.C. Journal, Vol. II, No. 2, August, 1940, pp. 83-95.) (83/27 Great Britain.)

The author attempts in this paper to give some idea of the various ways in which the X-ray crystallographic method of examination has been used in an industrial laboratory. Many of the illustrations chosen have emphasised how X-ray methods give information which cannot be obtained by chemical means, but there is no doubt that the most instructive solution to a problem is reached

only by utilising all the methods of investigation at our disposal. We must also envisage the addition of new instruments to reveal yet further properties of materials, and the method of electron diffraction may be mentioned as being better suited to the examination of surface phenomena than X-ray analysis. On the other hand, it is not always realised how wide is the scope of X-ray analysis, and how certain physical properties such as coefficient of expansion which have been measured in the classical manner have also been measured by X-ray methods. Such new measurements should not be regarded merely as repetitive, for new aspects of the physical property may be revealed by a fresh method of approach.

New conceptions are arising directly out of the recent measurements on lattice distortion and the lower limiting size of crystallites developed in a cold worked metal, and the gradual clarification and development of our picture of the ultimate structure of matter owes much, and will owe still more in the future, to the revealing and searching power of X-rays.

Strengthening Cylindrical Tanks of Variable Thickness Under External Pressure by Circular Stiffening Rings. (C. B. Biezeno and J. J. Koch, J. App. Mech., Vol. 7, No. 3, Sept., 1940, pp. 106-108.) (83/29 Germany.)

In a previous paper the authors discussed the buckling of a cylindrical tank of variable thickness under external pressure, and they developed a method by which the factor of safety against buckling was derived in numerical terms.

This present paper deals with the strengthening of a tank whose factor of safety is insufficient. Obviously, great help may be expected from one or two stiffening circular rings, adjusted in the upper part of the tank, where the thickness of the shell is small. The authors show how to calculate such rings.

Effects of a Change of Poisson's Ratio Analysed by Twinned Gradients (Boussinesq and Cerruti's Problem). (H. M. Westergaard, J. App. Mech., Vol. 7, No. 3, Sept., 1940, pp. 113-116.) (83/30 U.S.A.)

Some problems of elasticity have a simple solution for a particular value of Poisson's ratio. For example, Boussinesq's problem of a normal force and Cerruti's problem of a tangential force, acting on the plane surface of a semi-infinite solid, are solved when Poisson's ratio is half by referring to Kelvin's problem of a force at a point in the interior of an infinite solid. For, when Poisson's ratio is half, the solution of Kelvin's problem can be stated in terms of one principal stress at each point, acting along the radial line from the point of the load; the other principal stresses are zero; and one half of the total force may be assigned to one half of the infinite solid. For other values of Poisson's ratio terms must be added in the formulas for the displacements and stresses. The derivations that have been available are somewhat lengthy, especially for Cerruti's problem. The difficulties are reduced by a simple analytical device, here called " the twinned gradient." The displacement to be added by the change of Poisson's ratio is stated as the gradient of a potential except that one of the components is replaced by its twin, an identical component in reversed direction. This device also lends itself to a simplification of the analysis of stresses in a rotating thick disc.

Torsional Vibration in Geared Turbine Propulsion Equipment. (H. Poritsky and C. S. L. Robinson, J. App. Mech., Vol. 7, No. 3, Sept., 1940, pp. 117-124.) (83/31 U.S.A.)

Two alternative methods are presented by the authors for the determination of torques in the propelling machinery of ships when friction is taken into account. One is called the " direct method " while the other is called the " method of normal co-ordinates." By " normal co-ordinates " of a linear system is meant a set of co-ordinates for which E and F both reduce to a sum of squares (without product terms). These normal co-ordinates are proper linear combinations of the original variables, with constant coefficients. Their existence follows from a

well-known theorem in algebra which states that two quadratics may be simultaneously reduced to algebraic sums of squares by a proper choice of axes. The new method is described at length, showing the great saving of numerical work possible by its use when compared to the direct method.

The paper points out that at critical propeller speeds oscillatory torques are limited only by damping. Two types of damping are taken into account: One is damping of the propeller in water; the other is friction in the driving mechanism, introduced as solid friction in the shafts similar to damping in the metal.

Spot Welding of Aluminium for Aircraft. (L. P. Wood, Metal Progress, Vol. 38, No. 3, Sept., 1940, pp. 274 and 334.) (83/32 U.S.A.)

Whilst the cost of driving an average aircraft rivet varies between 1.5 and 3.5 cents, the corresponding spot weld only costs about 0.25 cents. The saving in time and money by spot welding is thus considerable. Nevertheless, the practice does not appear to have been adopted extensively in the U.S.A. except for certain semi-structural parts. In Europe, on the other hand, the use of spot welding has been much more general and it is stated that military aircraft now in action have a considerable amount of spot welds many in vitally stressed parts. One of the most successful welding machines for this purpose is the French Sciaky Welder, which embodies two new features: The use of D.C. current and a variable contact pressure cycle at the weld. The direct current is obtained in the following manner:—The normal three-phase shop circuit is converted by means of a mercury arc rectifier into a series of unidirectional impulses which pass through the primary of a choke transformer. When the field strength has reached a certain amount, the primary circuit is cut automatically and a transient D.C. current of high amperage is generated in a secondary winding connected to the welding circuit. The contact pressure device subjects the area to be welded to a high preliminary pressure. Immediately before the passage of the current this pressure is reduced, but applied again to the full amount when the transient current has diminished to about half its maximum value. The pressure is held whilst the metal is still hot and improves the grain structure of the weld.

The process has the further advantage that the preliminary cleaning of the surfaces can be dispensed with in certain cases.

Energy Losses in Impact Testing. (N. Davidenkoff, Metal Progress, Vol. 38, No. 3, Sept., 1940, p. 297.) (83/33 U.S.S.R.)

Impact tests carried out at the Zaporosh steel works showed consistent differences depending on the type of impact testing machine employed. The three machines utilised were:—

(1) Amsler, 15 kg.m. capacity.
(2) Losenhausen, 10 kg.m. capacity.
(3) Schopper, 30 kg.m. capacity.

And the average results obtained on a certain type of steel were:—

(1) 5.32 kg.m./cm.^{2}.
(2) 6.28 kg.m./cm.^{2}.
(3) 6.68 kg.m./cm.^{2}.

According to the author, the differences are due to energy absorbed by the pendulum rod, the highest losses corresponding to short, slender pendulums of high moment of inertia.

Another source of error arises when using pendulum machines for the impact testing of very brittle materials. The following table gives a comparison of the work of rupture kg.m./cm.^{2} of ceramic specimen by static and impact methods.

Static.	Impact.
0.037	0.77
0.033	0.51
0.0103	0.50
0.0314	0.62

The true energy absorbed is thus only 2-5 per cent. of that recorded by the pendulum. It appears that in this case nearly all the impact work is wasted in secondary losses, such as accelerating the fragments.

Use of Clad Metals in Germany. (W. Radeker, Metal Progress, Vol. 38, No. 3, Sept., 1940, pp. 292-293.) (83/34 Germany.)

Cladding is the term employed for the bonding of a nobler metal to a less noble base. This leads not only to the conservation of strategic materials, but the bonded product may have qualities which are superior to those of either of its constituents.

Considerable use is made of cladding on a steel sheet base, the following metals being used for the covering:—Copper, nickel, 18.8 chromium nickel, or a special scale and creep resistant steel.

The most common method of manufacture is by rolling at the welding temperature. Ordinary steel and stainless steel can be bonded by a duplex casting process. The bonding of steel and aluminium is complicated and not yet in commercial use for chemical apparatus.

Methods have been devised for evaluating the adhesive strength of such coatings. Some of the results obtained with a mild steel base are given below:—

Silver	...	...	21,000	lb. sq. in.
Copper	...	...	28,500	,,
Nickel	...	...	34,000	,,
18.8 stainless	...	...	35,500	,,

Welds in coated materials completely satisfy the requirements of tightness, mechanical strength and chemical stability. In general the base metal is electric arc-welded using covered electrodes. The seam is then thoroughly cleaned and the coated side welded using the coating material.

An interesting recent application of bi-metal plates is in the construction of heavy duty bearings. The coated plate is bent into the required shape and a special supplementary metallurgical treatment secures the required anti-friction properties.

Behaviour of Steels Under High Temperatures when Exposed to Alternating and Compressive Stresses. (*From the German.*) (Hempel and Ardelt, Metallurgia, Vol. 22, No. 130, Aug., 1940, p. 120.) (83/35 Germany.)

The heating of the test pieces was by electric air furnace and a hydraulic testing machine was used capable of applying a load up to 60 tons for static tensile and compressive tests, from zero to +40 tons, respectively, for repeating tensile, compressive and bending tests, and up to ± 20 tons for alternating tensile, compressive or bending tests. Preliminary tests were necessary to solve problems of procedure, and in regulating and distributing the temperature over the length of the test pieces. A new device was developed by which the rate of elongation could be determined and automatically recorded during a period of 10 hours with an accuracy of $\pm 0.5 \times 10^{-4}$ per cent. per hour.

The course of elongation at 500°C. was observed at static tensile and compressive stresses, as well as under alternating tensile compressive stresses for various average tensile stress values. The time elongation curves were of similar shape in all cases; they showed a rapid elongation during the first hours of the experiments, and afterwards a decrease in the rate of elongation.

In all cases the relation of the total and of the permanent elongation, as well as of the rate of elongation to the various mean tensile stresses, were determined at constant maximum stress. It is remarkable that even for the mean stress zero, *i.e.*, for equal positive and negative maximum stress—an elongation takes place. During static tensile and compressive tests it was found that the time elongation curves of the tensile tests on the carbon-molybdenum steel were con-

siderably higher than those of the compressive tests, equal load being provided in both cases.

The Problem of Fatigue Fracture C. (*From the German.*) (Metallurgia, Vol. 22, No. 130, Aug., 1940, pp. 126-127.) (83/36 Germany.)

Many attempts have been made to solve the numerous and complicated problems connected with fatigue fractures; but many contradictions and obscurities remain which need intensive and careful investigation. The object of the present work reported by Hempel is to clear the problem of the spreading of cracks; by changing the method of testing it should be possible to determine what effect the form of test piece, the quantity of the load and the kind of material have on the spreading of a fatigue crack, when exposed to bending stress. For this purpose, the magnetic powder method of investigation has been chosen making the cracks visible as quickly as possible. The number of stress reversals from the moment the crack could be identified to the moment when the experiment was stopped was used as a measure of the spreading of the fatigue crack. This number of reversals may be termed the crack reversals, while those necessary for final fracture may be called fracture reversals.

As far as solid specimens were concerned, the crack reversals increased more or less quickly up to a crack depth of about 0.04 in., according to the load above the fatigue strength, but this increase diminished with increasing crack depth; as soon as the middle of the section is approached, the process of final fracture starts, and is finished after a few hundred reversals.

In order to compare the results of solid and drilled test pieces the ratios of crack reversals to fracture reversals were plotted. These diagrams show that, under similar loads the form of the specimen is of much greater influence than the load and the material. With solid test pieces the starting of the crack can be perceived at 85 to 90 per cent. and with drilled test pieces at 30 to 60 per cent. of the fracture reversals.

When alternating bending stress with equal bending moment over the measuring length is applied, a fatigue crack of solid test pieces takes place, almost independently of the test piece diameter and of the material, after 70 to 90 per cent. of the fracture reversals.

The Creep Strength of 17 *Low Alloy Steels at* 1,000°*F.* (Metallurgia, Vol. 22, No. 130, Aug., 1940, pp. 127-130.) (83/37 Great Britain.)

The results of an investigation are given, the object of which was to determine the effect of composition and heat treatment on the creep strength of the common low alloy steels at 1,000°F. It is shown that the addition of chromium tends to lower the creep strength of carbon molybdenum steel, but this decrease may be partially offset by increasing the molybdenum content. The stability of carbon molybdenum steels is increased by the addition of chromium. Titanium or columbium improves the creep strength of chromium molybdenum steels, but silicon and aluminium affect their creep strength adversely.

Hard Facing to Resist Wear. (Metallurgia, Vol. 22, No. 130, Aug., 1940, pp. 133-134.) (83/38 Germany.)

Appreciation of the value of hard facing has greatly increased in recent years, largely as the result of the development of many processes of applying metals and alloys or treatments to surfaces which increase resistance to wear, corrosion, or both. Hard surfaces may be produced on metal parts of suitable composition by means of various forms of heat treatment, such as carburising, nitriding, induction hardening, flame hardening, etc.; by metal spraying; by electro deposition of chromium or other hard elements; by the fusion welding of hard alloys, or the cementing of special sintered carbides.

Zeyen gives five groups of hard-facing material in order of increasing wear resistance; alloy steels containing up to approximately 20 per cent. of alloy con-

stituents; iron base alloys containing over 20 per cent. of alloying constituents; non-ferrous cobalt-chromium-tungsten alloys; crushed tungsten carbide, which after welding, is embedded in a steel binder; and cast tungsten carbide inserts. The order of their toughness is approximately the opposite of wear resistance.

According to Le Van most steels can be readily hard faced, but those containing 0.50 per cent. carbon and over usually, must be heat treated, and the hard facing of high speed steel is unsatisfactory. Low alloy and stainless steels, grey cast iron, alloy cast iron, and nickel base alloys are also hard faced successfully. Brass, bronze, copper and aluminium alloys are difficult to hard face, because of their relatively low melting points.

Hard facing metals and alloys are applied by either electric or oxy-acetylene welding processes, though non-ferrous alloys are best applied by means of the oxy-acetylene process.

With the metallic arc, a certain amount of inter-alloying is unavoidable, although it can be kept at a minimum through careful control.

Dimensionless Coefficients Applied to the Solution of Column Problems. (K. G. Merriam, J. Aeron. Sci., Vol. 7, No. 11, Sept., 1940, pp. 478-480.) (83/39 U.S.A.)

The simple Euler equation for the crippling load P of a slender strut with both ends free is given by

$$\frac{P}{A} = \frac{\pi^2 E}{(l/r)^2} \qquad . \quad . \quad . \quad . \quad . \quad (1)$$

where l = length of strut.
r = radius of gyration
A = area
} of most highly stressed section.

The more generalised Johnson formula gives

$$\frac{P}{A} = S - \frac{S^2 (l/r)^2}{4\pi^2 E} \qquad . \quad . \quad . \quad . \quad . \quad (2)$$

where S = max. compressive stress corresponding to load P. If, finally, the strut is loaded eccentrically

$$S = \frac{P}{A}\left[1 + \frac{ec}{r^2} \sec\left(\tfrac{1}{2}\sqrt{\frac{P}{A}} \cdot \sqrt{\frac{1}{E}} \cdot \frac{l}{r}\right)\right] \qquad . \quad . \quad . \quad (3)$$

where e = lever arm of eccentric force.
c = distance from axis of bending to the point of maximum compressive stress.

Putting

$$P/A = \alpha S$$
$$l/r = \beta\{2\pi\sqrt{(E/S)}\}$$
$$\theta = \pi\beta\sqrt{\alpha}$$
$$\gamma = ec/r^2, \text{ i.e., } e = \gamma r^2/c.$$

Equations (1), (2) and (3) above assume the simple form

(1) $4\alpha\beta^2 = 1$
(2) $\alpha + \beta^2 = 1$
} central loading.
(3) $\alpha[1 + \gamma \sec\theta] = 1$ (eccentric loading).

With truly central loading, $\gamma = 0$. Experimental results obtained under these conditions can, however, be represented by equation (3) if $\gamma = .1$, which is thus a measure of the accidental eccentricity usually present.

In practice, P, l, γ, E and S are usually known and A and r have to be determined.

The author attacks this problem by introducing a further factor

$$\lambda = (\pi^2/S)(E/S^2)(P/l^2)(r^2/A) = \alpha/20\beta^2.$$

This factor is a constant for geometrically similar cross-sections, constant load and length and a given material.

Assuming a given shape, it is thus possible to express α in terms of β. A second relation between α and β is given by (3) (with γ as parameter). For a given value of γ it is thus possible to solve for α and β by plotting the two series of curves and thus obtain the required values of A and r.

Effective Pitch. (J. Lockwood Taylor, Engineering, Vol. 150, No. 3,895, 6/9/40, p. 183.) (83/40 Great Britain.)

The effective pitch is defined as the advance per revolution at which the thrust of the screw propeller vanishes. The ratio of effective to geometric pitch is called the pitch factor.

Where effective pitch is retained as the normal design basis, in conjunction with standard series results, the pitch factors used should be the actual model values, including the effect of section thickness ratio, since this affects the incidence for zero lift. An allowance for scale effect from model to full-scale is possible only if independent aerofoil characteristics are available for the particular type of section over a sufficient range of the Reynolds number. In the case of ship propellers, empirical modification of the model pitch factors to cover such matters as cavitation loss and the possible under-estimation of ship effective horse-power, is to be avoided, as these should be separately estimated. It is possible, of course, to arrive at a correct face pitch using an incorrect effective pitch together with an incorrect pitch factor, but the working conditions of the screw are then in doubt; in particular, the unit thrust loading may not be as designed, and there may be a departure from optimum efficiency.

An Improved Type of Cup Anemometer. (P. A. Sheppard, J. Sci. Inst., Vol. 17, No. 9, Sept., 1940, pp. 218-221.) (83/41 Great Britain.)

A new design of three-cup anemometer is described possessing the following characteristics:—(i) The minimum wind velocity in which the anemometer will function quite satisfactorily, about 0.2 m./sec. (40 ft./min.), is appreciably lower than usual with this type of anemometer, and compares favourably with other sensitive but more troublesome types of anemometer involving moving parts. (ii) The rate of rotation of the cups is related linearly with the wind velocity, and in consequence the indicated mean value of the velocity in a gusty wind is true, apart from the effects of inertia. (iii) The inertia of the moving parts is small so that the anemometer is very responsive to changes in wind velocity and over-estimation in a gusty wind is negligibly small. (iv) The anemometer is portable and of relatively small dimensions.

High Altitude and its Effect on the Human Body (I). (W. M. Boothby, W. R. Lovelace and O. O. Benson, J. Aeron. Sci., Vol. 7, No. 11, Sept., 1940, pp. 461-468.) (83/42 U.S.A.)

The paper deals mainly with experiments carried out in a high altitude test chamber and describes improvements carried out by the authors in their well known B.L.B. oxygen inhalation apparatus.

Under normal conditions the partial pressure of the oxygen in the alveoli of the lungs is of the order of 100 mm. and should not diminish below about 60 mm. for any length of time, as otherwise ill effects develop progressively (fatigue, errors of "judgment"). Experiments show that up to about 15,000 feet, the partial pressure of the oxygen in mm. Hg. is given by the straight line relationship

$$P_{O_2} = (B - 47) \times O_2 - 40/R.Q.,$$

where B = barometer at altitude in mm. Hg.

O_2 = percentage concentration of O_2 in air breathed.

$R.Q.$ = respiratory quotient depending on food being digested.

The two constants (47) and (40) correspond respectively to the saturated vapour pressure (H_2O) at body temperature and average CO_2 pressure in alveoli. $R.Q.$ = 1 in case of sugar and 0.7 for fatty foods.

Using the former value, it appears that the oxygen partial pressure in the lungs becomes zero at about 30,000 feet when breathing air, and this limit is raised to 50,000 feet for pure oxygen. At lower altitudes, in order to maintain an oxygen partial pressure of the order of 100 mm., it is therefore necessary to breathe pure oxygen and the requisite rates of flow vary between about half litre per minute (N.T.P. dry) to 1.7 litre/minute for the altitude range 10,000 to 30,000 feet. These figures have to be increased by 50-100 per cent. if the aviator is specially active.

The inhalator developed by the authors is of the " open " circuit type, and the principal improvement in the latest type is the substitution of a simple automatic air regulator valve made of sponge rubber for the rather complicated metal device of the previous models. The mask is now of the oronasal type and a radio microphone is fitted.

Special " arctic " rubber is used throughout so that the mask and especially the reservoir bag will retain their flexibility at low temperature (−40°F.).

Measurements of the Noise from Aerofoils and Streamline Wires. (W. F. Hilton, Phil. Mag., Vol. 30, No. 200, Sept., 1940, pp. 237-240.) (83/43 Great Britain.)

Observations and measurements of noise in the high speed wind tunnel at the National Physical Laboratory, show that the noises can be classified into three main classes, designated (*a*), (*b*) and (*c*) for convenience. Class (*a*) consists of rushing noises similar to those produced by the empty tunnel, which can be considerably reduced by using ordinary acoustic absorbents, or rendered unobjectionable to the experimenter by wearing special ear plugs.

Noises of class (*b*) are whistling sounds of high, but very definite musical pitch, occurring at any speed below the shock-stall, and causing the greatest annoyance. It is found that this class of noise may be entirely eliminated by roughening the surface producing them. The singing noise made by exposed streamline wires on some aeroplanes could probably be eliminated by the method of surface roughening described in this report.

Class (*c*) noises occur on sections having a thickness greater than 15 per cent. of the chord, at about the shock-stalling speed. The noise is very loud (110 to 120 decibels), relatively low-pitched, and only partially silenced by roughening the surface.

In addition, observations are recorded on the effects of material (none), scale (small effect), incidence (small effect), thickness (pronounced effect on class (*c*)), and on sharp leading and trailing edges (marked effect on class (*b*)).

Some Acoustical Source Observer Problems. (S. W. Redfearn, Phil. Mag., Vol. 30, No. 200, Sept., 1940, pp. 223-236.) (83/44 Great Britain.)

The relation between the intensity of a sound of a definite frequency at a given point in a field and the characteristics of a source as defined either by the nature of the limit of velocity potential as the source is approached, or by other means for extended sources such as the displacement or pressure, is governed by the physical properties and geometrical distribution of various regions of the field or objects within it, and it is the purpose of the present paper to discuss the theory of certain reasonably simple systems. One general proposition linking source and point of observation is the reciprocal theorem of Helmholtz, stating that the potential at O in a field due to a source at S is the same as that at S due to the same source situated at O.

The problems dealt with here as hinging round the general source observer problem follow a logical sequence in that they relate directly to the practical methods available for minimising the noise level at any given point due to an unavoidable source situated at another point. In the first place, a simple barrier may be erected, so that the sound reaching the point of observation in consequence

of diffraction is effective; but this is considerable when the barrier and distances from it are not somewhat large compared with the wave length of the sound concerned. Carrying such a process one step further, the barrier may be converted into a complete enclosure, made of material of given transmission, and surrounding the source, with the internal surfaces having a certain absorption for sound. Reciprocally from the point of view of the fundamental theorem the point of observation may be situated in a similar enclosure. Such enclosures may have apertures in them either open or offering greater transmission than the main body of the enclosure. The detailed discussion then begins with a study of the barrier problem.

LIST OF SELECTED TRANSLATIONS.

NOTE.—Application for the loan of copies of translations mentioned below should be addressed to the Secretary, Ministry of Aircraft Production (R.T.P. 3), Thames House, Millbank, S.W.1, and copies will be loaned as far as availability of stocks permits. Lists of selected translations have appeared in this publication since September, 1938.

TRANSLATION NUMBER AND AUTHOR.		TITLE AND JOURNAL.
		ARMAMENTS AND THEORY OF WARFARE.
1101	Schmidt, A.... ...	*On the Energy and Power of Explosives on Detonation.* (Z.G.S.S., Vol. 30, 1935, pp. 33-151.)
1103	Kuhlenkamp, A. ...	*Fuses for Anti-Aircraft Shells.* (Z.V.D.I., Vol. 84, No. 18, 4/5/40, pp. 301-5.)
1107	Chaville, P.	*Shell versus Armour.* (La Science et la Vie, Vol. 57, No. 276, June, 1940, pp. 505-573.)
		AERO AND HYDRODYNAMICS.
1042	Göthert, B. ... ... Ribnitz, W.	*The Air Resistance of Floats and Flying Boat Hulls.* (Luftwissen, Vol. 6, No. 3, March, 1939, pp. 101-107.)
1105	Ferrari, C.	*Determination of the Pressure Exerted on Solid Bodies of Revolution with Pointed Noses Placed Obliquely in a Stream of Compressible Fluid at Supersonic Velocity.* (Atti della Reale Accademia delle Scienze di Torino, Vol. 72, Nov.-Dec., 1936, pp. 140-63.) (War Office Translation No. M.I.I.T. 9238.)
1110	Joukowsky, V. ...	*On the Measurement of the Temperature of Gases Flowing at Very High Speeds.* (Tech. Phys., U.S.S.R., Vol. 5, No. 12, Dec., 1938, pp. 968-994.)
		AIRCRAFT AND ACCESSORIES.
1104	Jacobs, H. ... ... Wanner, A.... ...	*D.F.S. Diving Brakes on Gliders and Power Aircraft.* (Jahrbuch der deutschen, L.F.F., Vol. 1, 1938, pp. 313-8.)
1109	Egorov, B. N. ... Kuznetsor, V. A. ...	*Tandem Airscrews.* (Trans. C.A.H.I., No. 87, 1931, pp. 5-67.)
		WIRELESS AND ELECTRICITY.
1108	Wessel, W.... ...	*The Passage of Electric Waves Through Wire Grids.* (H.F. Technik, Vol. 54, No. 2, Aug., 1939, pp. 52-60.)

ABSTRACTS FROM THE SCIENTIFIC AND TECHNICAL PRESS.

Issued by the
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(Prepared by R.T.P.)

No. 84. November, 1940.

On Maintained Convective Motion in a Fluid Heated from Below (Digest). (A. Pellew and R. V. Southwell, Proc. Roy. Soc., Vol. 176, No. 965, 9/10/40, pp. S62-S63.) (84/1 Great Britain.)

This paper examines the stability in viscous liquid of a steady régime in which the temperature decreases with a uniform gradient between a lower horizontal surface which is heated and an upper horizontal surface which is cooled. The problem has been treated both experimentally and theoretically by Bénard, Brunt, Jeffreys, Low and Rayleigh, and it is known that instability will occur at some critical value of $gh^3\Delta\rho/\rho kv$, h denoting the thickness of the fluid layer, $\Delta\rho/\rho$ the fractional excess of density in the fluid at the top as compared with the fluid at the bottom surface, k the diffusivity and v the kinematic viscosity. The critical value depends upon the conditions at the top and bottom surfaces, which may be either " free " or constrained by rigid conducting surfaces.

The theoretical problem is solved under three distinct boundary conditions, and greater generality than heretofore is maintained in regard to the " cell pattern " which occurs in plan. In addition, an approximate method is described and illustrated, depending on a stationary property akin to that of which Lord Rayleigh made wide application in Vibration Theory.

Theory of Screw Fans. (Crawford, Engineer, 13/9/40, pp. 166-168.) (84/2 Great Britain.)

The author develops equations for the design of fans to give not only uniform distribution of thrust but also constant axial velocity and static pressure. Curves are reproduced showing the values of blade angle and width at any radius, from which appropriate values may be selected for any value of total head and speed of rotation. The effect of blade thickness is also discussed and expressions for overall efficiency are derived. The author claims that fans designed on the basis suggested will also satisfy conditions of strength. Illustrated with one diagram and three graphs.

(Abstract supplied by Research Department, Metropolitan-Vickers.)

Experiments on the Breakdown of Laminar Flow. (A. Fage, J. Aeron. Sci., Vol. 7, No. 12, Oct., 1940, pp. 513-7.) (84/3 U.S.A.)

The paper deals with experiments, now in progress at the National Physical Laboratory, on the breakdown of laminar flow, and particularly that of transition from laminar to turbulent flow in a boundary layer. The work undertaken so far has been of an exploratory nature only, but the progress made is sufficient

to indicate that interesting results are likely. The experiments are being made in a water tunnel, closed return type, designed for the study of transition phenomena on long streamline bodies. General indications of the nature of the flow in the water tunnel have been obtained from the behaviour of a fine jet of coloured liquid, issuing into the stream from a tube of fine bore. Photographs of filament bands so obtained are given. These observations suffice to show that the flow down the observation chamber is free from diffused turbulence up to a high Reynolds number. Provision is made to view the flow in a boundary layer in the free stream under a microscope, the technique of observation used being based on that described in previous papers. Experiments to determine the influence of turbulence, wavy unsteadiness, and downstream pressure gradient on transition are now in progress.

The Spectrum of Turbulence. (J. Kampé de Fériet, J. Aeron. Sci., Vol. 7, No. 12, Oct., 1940, pp. 518-9.) (84/4 U.S.A.)

The author begins by investigating the problem of the nature of the spectrum of isotropic turbulence, *i.e.*, whether the frequencies of the fluctuations form discrete lines in the spectrum, whether they are distributed over a wide range (band spectrum), or whether they may be described as a combination of a line and a band spectrum.

The theoretical work previously reported by the author, and its comparison with the experiments of Simmons and Dryden indicated that the spectrum of isotropic turbulence is of the pure band type.

The author describes a method developed at the Institut de Mécanique des Fluides de Lille for investigating the turbulence spectrum from another standpoint, *i.e.*, through measurements of the dispersion of small soap bubbles subjected to turbulent agitation speeds.

It appears that the new experimental results are in good agreement with predictions based on the band spectrum theory.

The Effect of Flow Rectifiers Placed Behind Bends in Pipes. (E. Zimmermann, Z.V.D.I., Vol. 84, No. 19, 11/5/40, pp. 330-331.) (84/5 Germany.)

The accurate measurement of gas flow by means of throttle plates pre-supposes that the gas passes the throttle without a rotary flow component. It is often necessary to instal such throttles in close proximity to pipe bends which are known to produce rotary motion in the gas stream. The author investigated the efficiency of various types of commercial rectifiers in neutralising this effect. Flow surveys covering direction and velocity were carried out both with the usual type of angle pitot and with an anemometer.

It appears that if the pipe bend is not too sharp ($R/d \geqq 3$, where R = radius of curvature and d = diameter) the flow rectifier need not exceed $0.5\,d$ in length in order to produce reliable flow meter readings.

Cavitation of Hydraulic Turbine Runners. (R. E. B. Sharp, Trans. A.S.M.E., Vol. 62, No. 7, Oct., 1940, pp. 567-575.) (84/6 U.S.A.)

This paper contains a brief analytical discussion of runner cavitation. The cavitation equipment of the Baldwin Locomotive Works is described, and results with this apparatus are compared with those of the Holtwood laboratory. Stroboscopic apparatus for photographing runners during operation under cavitating conditions is illustrated, and various photographs above and below the sigma break are reproduced and discussed.

The sigma break of any hydraulic turbine runner is considered as the value of sigma at which the performance characteristics begin to undergo a change due to cavitation. This value increases with the specific speed of the runner, *i.e.*, the greater the specific speed, the greater, in general, must be the allowance for pressure drop $H_b - H_s$, on the back of the blades in the usual Thoma formula.

Sigma $= (H_b - H_s)/H$ with H_b as the height of the water barometer and H_s the vertical distance from the centre line of the runner; or more strictly, from the local point of lowest pressure on the blade, to the tailwater elevation. The reason for this increasing value of $H_b - H_s$ with increasing specific speeds is due to several factors, namely, the greater pressure differential necessary on the two sides of the blades, the greater absolute velocity, and greater relative velocity at discharge.

Civil Air Transport Communication (with Discussion). (A. D. Hodgson, J. Inst. Elec. Eng., Vol. 87, No. 525, Sept., 1940, pp. 317-350.) (84/7 Great Britain.)

Any form of transport calls for a communication and signalling system, and by its nature civil air transport has to rely on radio-telegraphy and radio-telephony for the majority of the services it requires, and is peculiarly dependent on navigational help by radio. As a result an extensive communication system has been built up to provide these services throughout the world, a system which is closely interconnected internationally and which provides a service for the aircraft of any country operating on the various routes.

The author gives a description of the pre-war system in this country and its immediate connections to the Continental and Empire networks, with some reference to the American system as an indication of the general differences between American and European practice.

The paper is divided into the following sections:—

(1) The growth of the communication system.
(2) Technical considerations and requirements of ground station equipment.
(3) Aircraft radio equipment and installation.
(4) The Atlantic and Empire routes to the East.
(5) A brief outline of the communication system in the U.S.A.
(6) Future developments, such as:—
    (1) Equi-signal track beacons on frequencies of the order of 33-38 Mc./s., and even higher.
    (2) Improvements in blind approach and landing systems, including a true glide path.
    (3) Development of an absolute altimeter.
    (4) High frequency direction finding.
    (5) Devices for providing warning of collision.
    (6) Homing devices on frequencies of the order of 33-38 Mc./s.
    (7) Direction finding (free from polarisation errors) for use on aircraft.
    (8) The coupling of a blind approach and landing system with an automatic pilot equipment.
    (9) The coupling of homing devices with automatic pilot.
    (10) Balloon meteorological sounding.

Perhaps we may look forward to types of aircraft planned to facilitate application of radio communication and navigational aids. By the use of moulded plastics we may even see aircraft produced with an insulated section enabling the fuselage to be used as a radiating system.

Graphical Solution of the Bending Aileron Case of Flutter. (W. B. Bergen and L. Arnold, J. Aeron. Sci., Vol. 7, No. 12, Oct., 1940, pp. 495-508.) (84/8 U.S.A.)

Based on the mathematical work of Theodorsen (N.A.C.A. Report No. 496) and Kassner and Fingado (A.M. Translation No. 406) the authors have developed a system of charts which enables the flutter speed range to be determined fairly simply for the two-dimensional case, provided the following design factors are known:—

b = semi-chord of wing.
k = ratio of mass of a cylinder of air of diameter $2b$ to the mass of the wing both taken for equal length along the span.
c = distance of aileron hinge from bending axis of wing divided by $b/2$.
x_β = " reduced " distance of C.G. of aileron from hinge.
r_β = " reduced " radius of gyration of aileron.
w_β = frequency of torsional vibrations of aileron about hinge.
w_h = frequency of bending vibrations of wing.

If $w_\beta / w_h > 1$, the flutter speed range diminishes with reduction in aileron mass balance and the lower and higher speed limits ultimately coincide for a " critical " value of x_β. For design purposes, it is therefore only necessary to balance the aileron up to this value to preclude flutter in this mode. The authors show how this critical value of x_β can be obtained from his curves by a method of trial and error.

It is the authors' opinion that an exact mathematical treatment of the three-dimensional case is neither practical nor justified, bearing in mind the complications due to non-homogeneity of wing structure, concentration of masses and extensive use of structural cut outs.

The problem is best approached by modifying the two-dimensional theory by the introduction of proper parameters, mainly based on experience, but checked wherever possible by means of models and full-scale experiments. Progress along these lines has been retarded in the past by the very laborious calculations involved. It is the authors' hope that the new graphical method of presentation proposed will be of use in development work.

Oxygen Boosting of Aeroplane Diesel Engines. (P. H. Schweitzer, Mech. Eng., Vol. 62, No. 10, October, 1940, pp. 719-722.) (84/9 U.S.A.)

By increasing the oxygen concentration from the normal 21 per cent. to 45 per cent., the indicated horse-power of a $3\frac{1}{4}$ by $4\frac{1}{2}$ in. four-stroke Diesel engine increased from 4.3 to 6, the brake horse-power from 2.9 to 4.05, the maximum cylinder pressure from 700 to 780 psi, the maximum rate of pressure rise, which is an index of the shock loading of the engine, decreased from 88 to 60 psi per deg., together with the ignition lag which was shortened from $9\frac{1}{2}$ to 5 deg. The specific fuel consumption increased from 0.43 to 0.59 lb. per i.h.p.-hr. or from 0.64 to 0.76 lb. per b.h.p.-hr., and the exhaust temperature increased from 620 to 1,000°F. under optimum timing conditions and with clear exhaust. The explanation for the favourable showing of the oxygen boost with regard to cylinder pressures and rates of pressure rise is obviously the extremely beneficial effect the oxygen has on the ignition lag which was about cut in half by the oxygen addition.

The deterioration of the specific fuel consumption—of no consequence by itself for a few minutes' operation—is partly due to the stretched injection duration necessary with the small capacity pump and nozzle designed and adjusted for a much smaller injection quantity.

With 55 per cent. oxygen concentration the power figures further increased somewhat, but at above 50 per cent. oxygen occasional detonation was experienced.

The author applies these results to a transport plane with 6,000 h.p. cruising and estimated engine weight of 2 lb. per h.p.

For the take-off 8,000 h.p. are necessary. To supply the additional 2,000 h.p., 200 lb. of oxygen is fed into the intake air during the take-off. The volume of 200 lb. of liquid oxygen is 20 gal. Standard liquid air containers of 55 litre capacity weigh 75 lb. Therefore the weight of the oxygen and container is 350 lb. while the possible saving in engine weight is 4,000 lb. The weight per take-off horse-power is thereby reduced from 2 to 1.54 lb.

Oxygen addition may be used for starting Diesel engines.

The raising of the oxygen concentration from the normal 21 per cent. to 45 per cent. was found to be equivalent to a rise of approximately 10 cetane number as far as starting is concerned.

Five per cent. increase in oxygen concentration eliminated exhaust smoke completely.

Toluene for T.N.T. Obtained from Petroleum. (Autom. Ind., Vol. 83, No. 6, 15/9/40, p. 277.) (84/10 U.S.A.)

Two methods of getting by-product toluene from petroleum can be used. The more important is the recovery of toluene in the production of high octane gasoline used in aircraft. It is estimated that supplies can be made available by this method at costs comparable to those prevailing at coke ovens. The second and more costly method, which could be used if emergency conditions required it, involves the " cracking " of other petroleum products. Experimental production of toluene from petroleum has indicated that this is an entirely practical source of supply and that large volumes could be made available in a relatively short time by the installation of additional recovery equipment.

Control of Smoke in the Automotive Diesel (with Discussion). (W. W. Manville, G. H. Cloud, A. J. Blackwood and W. J. Sweeney, J.S.A.E., Vol. 47, No. 4, Oct., 1940, pp. 397-408, 420.) (84/11 U.S.A.)

Improvement in the control of smoke in the automotive Diesel engine can be brought about by the use of lighter fuels of suitable ignition quality in cases where either design, maintenance, or adjustment fail to accomplish the degree of smoke control desired. But this control is accomplished by some reduction in power and a loss in fuel economy.

The satisfactory performance of the heavier fuels in European bus operation clearly shows that smoke control can be effected by other means than resorting to fuels approaching kerosene in volatility. The effect of cetane number on smoke is less important than the effect of volatility, except in cases where the ignition quality of the fuel is below the minimum demanded by considerations of roughness and cold starting.

The study reported in this paper not only covers the relationship between fuel properties and smoking, but also includes work on the effect of engine design, mechanical condition, and adjustment of the equipment on smoking. Not included in the programme are other problems associated with smoking and objectionable exhausts from Diesels, such as the related questions of odour, lubricating oil, and operating temperature.

Better Fuels for Better Engines (with Discussion). (W. H. Hubner, J.S.A.E., Vol. 47, No. 4, Oct., 1940, pp. 409-420.) (84/12 U.S.A.)

As the supplier of fuel energy for highway transportation, the petroleum refiner has the problem of producing gasolines on a mass production basis which will be satisfactory in many types of engines operated under widely different driving conditions. This problem is complicated by complex chemical and physical characteristics, both of the raw materials with which the refiner must work and of his finished products.

This paper reviews the refiner's solution to this problem from the viewpoint of the transportation and maintenance engineer, and discusses the trends of the major characteristics of gasoline, namely, volatility, anti-knock quality, sulphur content, gum content, and chemical composition. It suggests that the design of future engines will be in the direction of units of smaller size having higher compression ratios, yielding higher power output and greater fuel economy, and requiring fuels of higher anti-knock properties. The importance of low gum content and good storage stability is stressed. Sulphur content is becoming less

important so far as corrosion problems are concerned, and reduction in sulphur is now largely a question of the economics of producing high octane fuels.

The paper also describes the composition of modern fuels and the new refining methods of polymerisation, catalytic cracking, catalytic reforming, and alkylation.

Altitude and the Aircraft Engine. (E. F. Pierce, J.S.A.E., Vol. 47, No. 4, Oct., 1940, pp. 421-431.) (84/13 U.S.A.)

As long ago as 1933, Gagg and Farrar gave the following formula for the variation of full throttle h.p. or manifold pressure with altitude (constant r.p.m.):

$$\text{h.p.}_a = \text{h.p.}_o \{ \rho_a/\rho_o - (1 - \rho_a/\rho_o)/7{\cdot}55 \}$$

where ρ = atmospheric density and suffixes a and o refer to altitude and ground condition respectively. The equation was based on a large number of tests under simulated altitude conditions in a special test chamber and corresponds to a linear relationship between h.p. and density ratio. For all the types tested at the time, the full throttle h.p. at 20,000 feet amounted thus to 47 per cent. of the hypothetical ground value.

More recent flight tests on cyclone engines fitted with a dynamometer hub fully confirmed this formula. It was also found that all sea level lines of h.p. versus manifold pressure at constant r.p.m. are straight lines and all intersect at zero manifold pressure and a minus h.p. "F" which is characteristic of the engine and depends mainly on its displacement. It is interesting to note that this value of F determines also the slope of the constant manifold pressure line at altitude which amounts to 0.53 F at 20,000 feet regardless of manifold pressure or r.p.m. used.

The author further investigates the variation of specific fuel consumption with altitude under various conditions of supercharging. Experimental data on this point—especially as regards new designs—are rather meagre and estimates have thus to be based largely on empirical analysis. Speaking generally, when cruising at moderate altitudes (~ 10,000 feet) the specific fuel consumption is least when using the lowest possible blower speed and two-stage blowers with intercooler are generally detrimental to fuel consumption at altitudes below 20,000 feet.

Bendix-Stromberg Injection Carburettor. (Inter. Avia., No. 723, 19/8/40, pp. 1-4.) (84/14 U.S.A.)

The new carburettor has been developed primarily with a view to eliminating icing hazard, gravity and inertia effects as well as vapour lock tendencies. At the same time it is claimed that mixture control is rendered more accurate. In the usual type of carburettor, the petrol enters the air stream in the region of the choke tube, the fuel/air mixture subsequently passing the throttle, which is thus liable to freeze up unless special precautions are taken. In the new design the petrol is delivered under positive pressure by means of a pump to a point above the throttle, the flow being governed by a diaphragm subjected to the choke depression and operating valves in the fuel pump delivery circuit. A second diaphragm is placed in this circuit in order to damp out pressure variations of the pump. A by-pass circuit from the pump casing back to the fuel tank eliminates any fuel vapour that might upset the metering characteristics. With this new carburettor, the pilot may select at will any fuel/air ratio for a variety of operating conditions, such as lean cruising, rich cruising and full rich for take-off.

The desired fuel/air ratio is held constant by a special automatic mixture control unit which compensates for changes in air density and temperature. Nevertheless, the entire engine power can be used at all positions of the mixture selector lever. The regulation of the manifold pressure is not automatic in the models available, but must be effected by the throttle at all times.

Supply and Control of Lubricants in the Workshop. (P. Beuerlein, Z.V.D.I., Vol. 84, No. 19, 11/5/40, p. 317.) (84/15 Germany.)

A variety of oils and greases may be made use of in the same factory. To prevent waste and mistakes, it is recommended that each machine or machine tool be clearly labeled to indicate the corresponding lubricant, together with a chart showing last supply and date for replenishment. All points requiring lubrication should be clearly marked in colour and the corresponding lubricant should be stored or handled in containers bearing the same colour.

The same procedure should be applied to the collection of used oil. By storing the various types of old used lubricants in separate containers, regeneration is simplified.

Fuels for Diesel Engines in Marine Transportation. (W. F. Joachim and H. V. Nutt, Trans. A.S.M.E., Vol. 62, No. 7, Oct., 1940, pp. 595-604.) (84/16 U.S.A.)

After reviewing briefly developments in the field of Diesel fuels over the last 30 years, the authors discuss in detail the present day requirements for marine Diesel engine fuels. A summary of engine troubles and casualties caused by unsuitable fuels is also given. The paper includes a series of tables and explanatory matter concerning Diesel fuel specifications for various types of marine engines.

Sliding Electrical Contacts. (Windred, B.E.A.M.A. Journal, Sept., 1940, pp. 42/44.) (84/17 Great Britain.)

Electrical and mechanical phenomena associated with sliding electrical contacts are discussed, with particular reference to carbon or metallic graphite brushes in contact with a commutator or slip-ring. Following a brief review of factors determining the mechanism of sliding action, recent researches on the effective contact surface of electrical brushes, and the variation of the vertical contact area with pressure are described. An account is also given of experiments on the effect of surface films on the friction and resistance of a sliding contact, and on the effect of gases on brush wear and erosion. Vibration as a major factor in brush erosion is discussed as well as the general operating characteristics of metal graphite and carbon brushes, and the operation of brushes in parallel.

(Abstract supplied by Research Department, Metropolitan-Vickers.)

Modern Measuring Instruments. (Schlesinger, Machinery, 3/9/40, p. 12.) (84/18 Great Britain.)

The author concludes this outline of features of modern measuring instruments and principles of their design with a review of optical alignment testers and micro-comparator gauges. Optical alignment testing comprises the telescope and target method, the sighting telescope and collimator methods and the use of the auto-collimator. Under micro-comparators the author describes the electro-limit gauge and the solex pneumatic micrometer. Each instrument is described in some detail, with illustrations of commercial types, and the accuracy attainable is noted. Illustrated with six photographs and 11 diagrams.

(Abstract supplied by Research Department, Metropolitan-Vickers.)

"Total Energy" Variometer for Detecting Upward Currents in the Atmosphere. (A. Kantrowitz, J. Aeron. Sci., Vol. 7, No. 12, Oct., 1940, p. 523.) (84/19 U.S.A.)

When a sailplane is zooming or diving, it is gaining or losing altitude energy at the expense of kinetic energy. It is, however, changing its total energy (altitude energy + kinetic energy) at a rate which depends only on its drag and atmospheric air currents. Thus, if we measure the rate of change of total energy instead of just altitude energy, we will have a measurement of atmospheric

currents and sinking speed independent of the plane's attitude. Furthermore, total energy is the quantity in which the soaring pilot is interested in increasing. The total energy of a plane of mass m flying at a velocity v at an altitude h is

$$\tfrac{1}{2} mv^2 + mgh$$

and it is thus proportional to $\tfrac{1}{2} v^2 + gh$.

In the usual design, the atmospheric outlet of the variometer is connected to the static head where it is exposed to the altitude pressure—ρgh (ρg is the density, h the altitude, and pressure is measured from sea level pressure). Now, consider the variometer outlet to be connected to the throat of a venturi with a contraction ratio of $\sqrt{2}$ which will produce a pressure drop equal to the dynamic pressure $\tfrac{1}{2} \rho v^2$. In this case the variometer will be exposed to a pressure—$\rho gh - \tfrac{1}{2} \rho v^2$.

Thus, this negative pressure is also proportional to $\tfrac{1}{2} v^2 + gh$ which is just the measure of the sailplane's total reserve of energy. Therefore, if a conventional variometer were connected in this manner it would read rate of change of total energy in altitude units. A variometer so connected may be called a "total energy variometer." With a total energy variometer it should be possible to measure upward air currents, even in rough air when the attitude of the ship is continually changing, without making any corrections.

A Recording Optical Manometer for Transient Pressures. (P. B. Smith, J. Sci. Inst., Vol. 17, No. 10, Oct., 1940, pp. 242-245.) (84/20 Great Britain.)

This paper describes a manometer capable of being used to record pressures caused by the explosion of gaseous mixtures in vessels totally or partially closed. Permanent records are obtained as time-deflexion graphs on a light sensitive film (bromide paper). The maximum deflexion available is approximately 4 cm. and the range of pressures which can be made to correspond with this deflexion is capable of wide variation. The natural frequency of the recording system (in which there are no loose coupled parts) is high and is an inverse function of the sensitivity.

Combined Tension-Torsion Tests on a 0.35 per cent. Carbon Steel. (E. A. Davis, Trans. A.S.M.E., Vol. 62, No. 7, Oct., 1940, pp. 577-586.) (84/21 U.S.A.)

This paper contains the results of a group of combined tension-torsion tests on both cylindrical and notched bars. The author has tried to keep in mind the close relation between this type of test and the problem of bolting. The test results show the amount of reduction in the ultimate tensile strength when a torque is applied in combination with the tension load. They also show a similar reduction in the torsional strength when a tensile load is added.

At this point, an interesting observation can be made concerning the combined tension-torsion tests. In a pure torsion test, the moment angle diagram has a positive slope until the fracture occurs, and the bar carries its maximum torque just the instant before it fails. In the combined stress tests, where the tensile stress was fairly high, the torque reached a maximum an appreciable time before failure. This may possibly be due to the fact that the diameter of the bar becomes considerably reduced when it is stretched in tension, thus increasing the shear stress without increasing the applied moment.

Thermal and Electrical Conductivities of Metals and Alloys. (W. F. Chubb, Phil. Mag., Vol. 30, No. 201, Oct., 1940, pp. 323-329.) (84/22 Great Britain.)

From the author's review of the relationships existing between the thermal and electrical conductivities of metals and alloys, it may be concluded that the chief reason for the many anomalies that have arisen in regard to their interpretation lies in the relative inaccuracy of thermal conductivity determinations. Despite the many attempts to do so, it does not seem likely that an acceptable

theory of metallic conduction can be formulated until such time as sufficient thermal conductivity data of the required accuracy are available, calculation from other physical properties being of little value for these purposes. A method and procedure based upon the guard ring principle and capable of providing data of fundamental accuracy is, however, available.

Problems of Porosity in Aluminium Alloy Castings. (Engineering, Vol. 150, No. 3,900, 11/10/40, p. 296.) (84/23 Great Britain.)

Although light alloy castings show some tendency to porosity troubles, they are by no means unique in this respect, some heavy metal alloys being still more prone to difficulties from this cause. Nevertheless, the characteristic chemical, physical and mechanical properties of aluminium alloys, in general, have a distinct influence on the degree and type of porosity and analogous defects which may occur in these materials when they are cast.

During the past five or ten years, however, much progress has been made and, although a complete solution to porosity troubles has not been found, the intensive research which is being carried out is making itself felt by distinct improvements, not only in the inherent high strength of many castings but in the uniformity of quality in mass production.

Even on comparatively small outputs of ordinary work, wasters have been reduced to a fairly common level of 5 per cent., while on large and long continued outputs of a given casting, a figure as low as 0.75 per cent. is sometimes claimed to have been arrived at. In the case of castings which have to pass severe tests for pressure tightness, on the other hand, wasters may average from 10 per cent. to 15 per cent.

Careful attention, the author continues, should be paid to melting procedure and it is urged that for furnaces other than those of the electric type, that is oil-fired or coke-fired furnaces, the design must be such that contamination of the charge by products of combustion is rendered virtually impossible. Moreover, when putting a furnace into operation, adequate precautions should be taken to ascertain that the refractories and the crucible have been rendered quite free from moisture.

A New Magnetic Alloy. (Engineer, Vol. 170, No. 4,423, 18/10/40, p. 252.) (84/24 U.S.A.)

At a recent meeting of the American Physical Society, E. A. Newbitt and G. A. Kelsall, of Bell Telephone Laboratories, New York, N.Y., introduced a magnetic alloy possessing remarkable qualities. It will be known as "Vicalloy," because its contents are vanadium, iron, and cobalt, the percentages ranging from 6 to 16 per cent. vanadium, 30 to 52 per cent. iron, and 36 to 62 per cent. cobalt. After melting it is cast into an ingot, which is hot swaged to $\frac{1}{4}$ in. diameter. It is then drawn into wire or rolled into tape as desired. When in final form, it is heat treated to develop its magnetic qualities.

Surface Hardening Machine. (Engineering, 20/9/40, pp. 227-228.) (84/25 Great Britain.)

A detailed description is given of a surface-hardening machine, recently introduced by Messrs. Shorter Process Company, designed for hardening spur gears, bevel gears, single and double helical gears and straight surfaces. The machine consists of a motor-driven burner head mounted so that it has both cross-traverse and longitudinal-traverse in a manner analogous to the compound slide of a lathe, the traverse taking place above a tank containing the work-supporting gear and the quenching water. The Ward-Leonard regulating set for the motor drive of the burner head, and special attachments are claimed to provide flexibility of operation and control, especially in hardening gears.

(Abstract supplied by Research Department, Metropolitan-Vickers.)

Suggested Methods of Testing Spot Welds. (Weld. J., Sept., 1940, pp. 333-34.) (84/26 Great Britain.)

The article gives a summary of methods of testing recommended by the Resistance Welding Committee of the Welding Research Committee. The tests fall into two groups: (1) Process qualification tests, (2) material weldability tests. In class (1) the main test is a tensile test from which the ultimate strength of one spot weld, the diameter of the weld slug, and manner of failure are observed. Dimensions of the test specimens, and testing procedure are described in detail. The tensile test is to be supplemented by a visual test on a cross section, chemical analysis, etc. In class (2) the standard lap shear test as used in (1) is to be supplemented by a tensile test on a U-shaped specimen. To ascertain whether fusion has taken place, as a preliminary to the standard tests, torsion tests and peel or pull-out tests may be employed.

(Abstract supplied by Research Department, Metropolitan-Vickers.)

How Should Engineers Describe a Surface? (O. R. Schurig, Mech. Eng., Vol. 62, No. 10, Oct., 1940, pp. 703-711.) (84/27 U.S.A.)

The geometrical characteristics of a surface profile are so numerous that the shape of a surface cannot be adequately described by a single parameter of its profile.

The following geometrical characteristics have been suggested or considered in connection with the description of a surface:—

(1) Maximum height from highest to lowest point.
(2) Average height above base line passing through lowest point.
(3) Form factor, being the ratio of average height to maximum height above base line.
(4) Root-mean-square average height with respect to centre line of profile.
(5) Prevailing wave length.
(6) Direction of irregularities above or below the prevailing surface contour.
(7) Direction of finish marks with respect to co-ordinates of the surface.
(8) Available contact area per unit nominal area.

Efforts should be concentrated to determine what geometrical qualities are important for surfaces used in different kinds of applications and in different industries. Once the significant qualities have been agreed on they should be used as a basis for standards covering the description and designation of surface quality. The standards should provide adequately for describing waviness, roughness, and surface flaws.

A designation of surface qualities including reference to a process of finishing may be useful in giving instructions in the shop, but the purpose of the standard is not to specify how the surface shall be made, but how it shall be described.

Fatigue of Screw Threads. (Smith, Iron Age, 22/8/40, pp. 23-28.) (84/28 Great Britain.)

The author describes experiments carried out to determine the effect of the method of manufacture of the thread on the ultimate tensile strength and on the fatigue limit. The preparation of the specimens and the method of testing are described, and the results tabulated. They indicate that cut threading has no apparent effect on the properties of the original material; single extruding and rolling of threads increases the ultimate strength and endurance ratio; and that double extruding and rolling threads increases the ultimate strength and endurance ratio the most, while considerably decreasing the tensile impact strength. The results also show that a round bottom thread has a higher endurance ratio than a thread with sharp corners at the bottom.

Illustrated with five photographs, one diagram and one graph.

(Abstract supplied by Research Department, Metropolitan-Vickers.)

Fatigue Failure. (Sachs, Iron Age, 5/9/40, pp. 31-34.) (84/29 Great Britain.)

Results of some experiments on the effect of notches and corrosion on fatigue strength are presented. Graphs are reproduced showing the effect of the sharpness of the notch, measured by the peak stress set up, and also the nature and strength properties of the metal upon the reduction of the bending and torsion fatigue strength by a notch, hole or fillet. The results indicate that within a specific group of alloys, such as the steels, the notch fatigue strength of high strength steels is almost constant and no benefit is derived from alloying, cold work or heat treatment. Corrosion fatigue is similar in many ways to fatigue caused by notches, and is dependent on the corrosive agent and the chemical and mechanical properties of the material. The article is to be continued.

Illustrated with two photographs and six graphs.

(Abstract supplied by Research Department, Metropolitan-Vickers.)

Butyl Rubber. (R. M. Thomas, I. E. Lightbown, W. J. Sparks, P. K. Frolich and E. V. Murphree, Ind. and Eng. Chem. (Industrial Ed.), Vol. 32, No. 10, Oct., 1940, pp. 1283-1292.) (84/30 U.S.A.)

This paper presents the results of a thoroughly unorthodox approach to the synthetic rubber problem. In developing their new butyl rubber, the Esso Laboratories have turned to simple olefins rather than diolefins or more complicated chemical derivatives as the main raw material. Not only is this an economic advantage, but the ready availability of such simple olefins from refinery cracking operations makes the process seem attractive from the standpoint of potential supply of synthetic rubber.

As only the limited amount of unsaturation required for curing with sulphur has been provided, the vulcanisates are substantially saturated and therefore possess the chemical stability characteristic of a paraffin hydrocarbon. In spite of this radical difference in internal structure, the polymer can be processed in much the same manner as natural rubber, and the physical properties of natural rubber have been retained to a surprising extent. Because of the low degree of unsaturation and consequent chemical inertness, the available information indicates that butyl rubber will be superior to natural rubber for many purposes.

Fatigue Failure. (Sachs, Iron Age, 12/9/40, pp. 36-40.) (84/31 Great Britain.)

This portion of the article deals with chafing fatigue, and the effect of surface working on the fatigue strength in the presence of stress raisers. Reports of many types of test are submitted, including tests on the relation between the chafing fatigue strength and the normal fatigue strength, the effect of grip pressure on the fatigue strength, the effect of various stress raisers with and without surface rolling, and the effects of surface rolling with different pressures. The investigations indicate that no benefit is derived from alloying, cold work or heat treatment if a strong chafing action is present. Illustrated with two photographs, one diagram and nine graphs.

(Abstract supplied by Research Department, Metropolitan-Vickers.)

Pulsation Welding. (Cogan and Pelton, Weld. Ind., Oct., 1940, pp. 249-50 and 252.) (84/32 Great Britain.)

An outline is given of the technique of pulsation welding, and recent progress in this field is reviewed. Results of tests on pulsation welded joints are submitted and the following advantages are claimed for this method, especially with spot and projection welding; electrode life is increased; thicker material can be welded in production than was practicable before; thicker material can be welded with the same equipment; any tendency of the weld metal to " spit " is reduced; and the finished appearance of the weld is improved. A description is included

of a vertical, hydraulically operated, pulsation butt welding machine, with full synchronous electronic timing control. Illustrated with one photograph.
(Abstract supplied by Research Department, Metropolitan-Vickers.)

Selection of Steel and Heat Treatment for Spur Gears. (Knowlton and Snyder, Trans. A.S. Met., Sept., 1940, pp. 687-708.) (84/33 Great Britain.)

Selection of the steel and type of heat treatment for case-hardened spur gears is discussed on the basis of the results of service experience and certain laboratory tests. Different types of gear failures, including wear or abrasion, breaking at the root, pitting at the contact area, breaking through the pitted area and chipping of corners of clashed teeth are described and discussed. It was found that with a variety of steels quenching directly from carburising was superior to double quenching so far as resistance to pitting was concerned. Some reference is made to different methods of testing gears, and a description is included of a new type of rolling fatigue machine to determine resistance to pitting. Illustrated with six photographs, eight diagrams, and four graphs.
(Abstract supplied by Research Department, Metropolitan-Vickers.)

A New Material for Gaskets. (Autom. Ind., Vol. 83, No. 6, 15/9/40, pp. 265-6.) (84/34 U.S.A.)

A new material for cylinder head and other gaskets has been developed in Germany to take the place of asbestos base gaskets (asbestos being a material not readily obtainable in Germany under present conditions). It is made up of three sheets or layers of the synthetic Buna rubber and two layers of steel wire netting, the wires of the two layers being placed at angles of 45 deg. with each other. Wire netting and rubber sheets are vulcanised together. Where the conditions of application make it desirable, metallic edging may be applied where the gasket is exposed to high pressure. Unlike natural rubber, which softens when exposed to high temperatures, Buna has a tendency to "tighten," and it can withstand high temperatures much better than natural rubber. Owing to the elastic nature of the rubber and the fact that the gasket is not coated with graphite, it is said to have better holding properties than conventional gaskets. The new gaskets are said to be resistant to hot water and hot oil up to 350 deg. Fahr., to glycol, gasoline, and leaded gasoline. They are not destroyed by adhering to the metal parts.

General Stress Analysis for Rings with One Axis of Symmetry. (H. P. Liepmann, J. Aeron. Sci., Vol. 7, No. 12, Oct., 1940, pp. 509-12.) (84/35 U.S.A.)

A general stress analysis for monocoque fuselage rings is presented, which is applicable not only to circular and elliptical rings, but also to any other shape which is symmetrical about a vertical axis. The formulæ developed apply to rings with either constant or variable moment of inertia. By proper choice of the system of co-ordinates the three unknowns are obtained directly from three equations instead of from three simultaneous equations. General equations for the circular ring are worked out, taking into account the difference of ring radius and skin radius.

Research on Combined Stress and Anisotropy. (J. J. Guest, Phil. Mag., Vol. 30, No. 202, Nov., 1940, pp. 359-369.) (84/36 Great Britain.)

This paper discusses the effect of departure from isotropism in the specimen on the yield point under various stress combinations, and analyses the experimental results and deductions drawn therefrom given in papers by Mason, Becker, and Cook. For ascertaining the effects of the simple forms of anisotropy which manufacture tends to leave in the product, it is assumed that the primary factor in elastic failure is the maximum shearing stress.

The application of these deductions to the researches referred to show that, for close correlation, an effect due to volumetric stress must be included, and that the various unexplained difficulties encountered in these researches are then completely clarified and all the results are shown to be in close agreement with the Guest criterion of elastic failure.

The completeness of the explanations of difficulties so diverse is good evidence that the assumption is correct, and the effects are shown to be such as to merit careful examination in future research.

A Contribution to the Theory of Elasticity of Non-Isotropic Materials (with Applications to Problems of Bending and Torsion). (E. Reissner, Phil. Mag., Vol. 30, No. 202, Nov., 1940, pp. 418-427.) (84/37 U.S.A.)

This paper contains a contribution to the two-dimensional theory of elasticity of materials of rectilinear anisotropy. The theory and its applications presented are very much simpler than the corresponding developments for isotropic materials. The simplification is due to the fact that one of the two moduli of elasticity which occur in plane stress is assumed equal to zero, which means that the material is not resistant to normal stresses in a certain direction. A material for which these assumptions are very nearly true is a corrugated sheet in which pitch and depth of the corrugations are small compared with the overall dimensions of the sheet.

In Part I the general theory is given, that is, expressions are developed for stresses and displacements in terms of arbitrary functions which have to be determined by boundary conditions. In Part II bending of a narrow rectangular beam is considered, and an exact solution—so far missing for a beam of isotropic material—is given which shows how the stress distribution depends on the way the beam is supported and the loading is applied. In Part III applications to the theory of bending of wide-flanged box beams are indicated. In Part IV torsion of box beams is treated, the end sections of which are restrained against warping. Some simple formulæ for the relation between Bredt's shear stress and the secondary normal stresses are given.

Standardisation of Terms in the Welding Industry. (Z.V.D.I., Vol. 84, No. 19, 11/5/40, pp. 325-329.) (84/38 Germany.)

The article reviews some new German Standard Specifications dealing with welding. These specifications are based on proposals discussed at the International Conference in 1927 and bring the matter up to date.

Specification E.1910 defines the various types of welding operations in use, covering both fusion and press welding.

E.1911 specifies the type of seam, the classification being according to cross-section, form of surface or position of weld (continuous or discontinuous welds). The last specification reviewed (E.1912) deals with the requisite symbols for indicating various types of welds on engineering drawings.

An Automatic Weather Station. (H. Diamond and W. S. Hinman, Bur. Stan. J. Res., Vol. 25, No. 2, Aug., 1940, pp. 133-148.) (84/39 U.S.A.)

An important contribution of radio to the collection of weather data consists in the possibility of utilising completely automatic stations installed at isolated locations, such as mountain peaks, islands, etc., whereby information on the meteorological factors of interest is automatically transmitted at predetermined intervals. Details are given of a method for the remote indication by radio of measurements of barometric pressure, air temperature, relative humidity, wind direction and velocity, rainfall, and other meteorological factors. The method was developed to meet requirements formulated by the Aerological Division, Bureau of Aeronautics, Navy Department, the work being done for that Service.

The method retains the operating principles of the audio-modulation type radio

sonde but, because of the use of much lower audio frequencies (0.15 to 3.0 cycles per second), affords important simplifications in the transmitting and receiving equipment. The low frequencies allow mechanical keying of a conventional radio telegraph transmitter, thereby avoiding the need for complicated modulating equipment. At the receiving end, the frequency measuring and recording functions are carried out by simple electric counters or by manual counting, which eliminate the expensive electronic-frequency meter and recording micro-ammeter used at radio-sonde ground stations.

An experimental installation set up at the Naval Air Station, Anacostia, D.C., using this method, is described and measurements for a 30-day period are analysed.

The Breaking Theory of Detonation (Part II). (L. R. Carl, J. Frank. Inst., Vol. 230, No. 3, Sept., 1940, pp. 355-374.) (84/40 U.S.A.)

A new theory has been proposed to clarify the phenomenon of the detonation of explosives, based on the recent progress in the knowledge of crystal and molecular structure. The main contentions of the new theory are:—

That detonation is the progressive breaking of the valence bonds of compounds, by distortions, transmitted as elastic waves. The resulting products of detonation recombine with release of energy which maintains the wave.

The materials which are most readily detonated and which readily transmit detonation are the truly elastic materials (regular crystals).

Sensitivity is the most inherent characteristic of explosives, and is conditioned by two types of instability; surface instability caused by surface unsaturation, and internal instability caused by internal unsaturation (endothermic compounds).

Any state of matter or agency which tends to prevent the distortion of the molecule or crystal, will also tend to reduce the sensitivity. Any state of matter or agency which tends to increase the strength of the crystal or molecule will also tend to reduce the sensitivity.

All materials which tend to damp out elastic waves will transmit detonation imperfectly.

The breaking or detonation wave may penetrate any material and may, therefore, be considered a universal phenomenon.

High Altitude and its Effect on the Human Body (II). (W. M. Boothby, W. A. Lovelace and O. O. Benson, J. Aeron. Sci., Vol. 7, No. 12, Oct., 1940, pp. 524-530.) (84/41 U.S.A.)

Rapid ascent to high altitude is dangerous, since the gases normally dissolved in the tissue fluid and blood stream of the aviator are released, leading ultimately to symptoms similar to those occurring when a deep sea diver ascends without gradual decompression. (Light headedness, smarting of the eyes, crawling sensation over the skin, pains in the joints leading ultimately to paralysis and collapse.) The danger zone starts at about 18,000 feet, if no precautions are taken. The authors have carried out a large number of simulated ascents in a low pressure chamber from which appears that preliminary breathing of pure oxygen for a period of about 30 minutes (provided the subject undergoes a certain amount of physical exercise during the process) will lead to the gradual elimination of the gas bubbles (mainly nitrogen) from the body, and will render subsequent ascents to high altitudes perfectly safe, provided the oxygen breathing is continued at the requisite rate. The authors also investigated the case of parachute descents from very high altitudes (~ 30,000 feet). Oxygen breathing during the early stages of drop is essential and the authors have devised a simple form of mask for this specific purpose. After calling attention to the need of careful calibration of oxygen flow meters under altitude conditions, the authors sketch out a training course for high altitude flying. A series of individual altitude chambers accommodating only one pupil each are recommended as being cheaper and more useful than the provision of large chambers holding a number.

Prize Offered by the German Government for the Development of a New Type of Electrical Accumulator. (Z.V.D.I., Vol. 84, No. 19, 11/5/40, p. 317.) (84/42 Germany.)

The three types of accumulators at present in use are:—

(1) Standard lead accumulator.
(2) Ni-Fe accumulator (Edison).
(3) Ni-Cd-Hg accumulator (Jungner).

All the above necessitate the utilisation of materials which have to be imported into Germany. The object of the prize is to further research on a new type utilising home produced materials such as carbon, zinc, iron, as well as easily manufactured organic or inorganic substances. The range of substances utilised should be as small as possible and replacements should not be required more than once a year. The new accumulator when discharged must be stable and stand storage for a period of at least ten years without detrimental effects, *i.e.*, after such a lapse of time it should be possible to recharge it. Other requirements are small weight and size, reliability and high E.M.F.

The competition is organised by the army authorities and the closing date is 1/1/41. (The value of the prize offered (10,000 R.M.) appears to be very low.)

A.R.P. Measures in Industry and the Health of the Worker. (Z.V.D.I., Vol. 84, No. 19, 11/5/40, p. 324.) (84/43 Germany.)

Care for the health of the worker should always be one of the primary considerations of any government. This is especially the case in war time when man/hours are of the greatest importance. It is essential that factory lighting during black-out periods should be efficient. Reference is made to the use of luminous paints in certain localities. One of the main difficulties in industrial concerns is to provide ample ventilation during black-out periods and this applies especially if dust, smoke, or steam are present, or if a considerable amount of heat is generated. Certain machining operations normally carried out without difficulties become dangerous under black-out conditions. Here much can be done by choice of machine tools and order of operations.

Properties of Hydrogen Mixtures. (A. W. Brunot, Trans. A.S.M.E., Vol. 62, No. 7, Oct., 1940, pp. 613-619.) (84/44 U.S.A.)

With the increased use of hydrogen as a cooling medium in rotating electrical machines, it has become important to know the properties of hydrogen diluted by small amounts of another gas. Using these properties it is possible to predict the operation of the machine in a hydrogen mixture from the results of tests made in air or pure hydrogen. The author presents a summation of data on the properties of hydrogen, air, nitrogen, and carbon dioxide, as well as empirical formulas for the properties of the mixture of hydrogen with any of the other three gases. It appears that the performance of a heat exchanger in hydrogen or hydrogen mixtures may be predicted from tests in air with an accuracy sufficient for practical engineering purposes.

Heat Transfer to Falling-Water Films. (W. H. McAdams, T. B. Drew, and G. S. Bays, Trans. A.S.M.E., Vol. 62, No. 7, Oct., 1940, pp. 627-631.) (84/45 U.S.A.)

Data are presented in this paper for heating water as it flows by gravity in turbulent motion down the inner walls of vertical copper pipes, ranging in height from 0.41 to 6.1 ft. Heat balances check within 5 per cent. and the temperature of the inlet water ranges from 38 to 140°F. The data are adequately correlated by the equation: $h = 120\ R^{\frac{1}{3}}$, where R = rate of flow and ranges from 600 to 15,000 lb. of water per hr. per ft. of width of stream, and h = individual coefficient

between tube surface and water layer. Steam-side and over-all coefficients are given. The rather inadequate data for streamline flow by gravity over nearly horizontal pipes (trombones) are reviewed.

LIST OF SELECTED TRANSLATIONS.

NOTE.—Applications for the loan of copies of translations mentioned below should be addressed to the Secretary (R.T.P.), Ministry of Aircraft Production, and copies will be loaned as far as availability of stocks permits. Suggestions concerning new translations will be considered in relation to general interest and facilities available.

Lists of selected translations have appeared in this publication since September, 1938.

THEORY AND PRACTICE OF WARFARE.

TRANSLATION NUMBER AND AUTHOR.		TITLE AND JOURNAL.
1111	——	*Anti-Aircraft Defence of all Arms (General Anti-Gas Service). Book 4. Gas Mask Testing Appliances.* (War Office Translation, No. M.I.1T. 9339.)
1114	Scholle, Dr.... ...	*Guiding Lines for Anti-Gas Protection.* (War Office Translation, No. M.I.1T. 9339.)
1116	Hollbach, O. ...	*German Aircraft Construction—Export Handbook of the Aircraft Industry. Section IXC. Accessories for Bomb Release Gear.* (Deutscher Flugzeugbau-Handbuch der Luftfahrttechnik, 1939.)
1117	Hollbach, O. ...	*German Aircraft Construction—Export Handbook of the Aircraft Industry. Section IXE. Bomb Sights.* (Deutscher Flugzeugbau-Handbuch der Luftfahrttechnik, 1939.)

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1051	Görtler, H.	*Further Development of a Boundary Layer Profile for a Given Pressure Distribution.* (Z.A.M.M., Vol. 19, No. 3, June, 1939, pp. 129-140.)
1102	Santangelo, G. ...	*High Velocities and High Wing Loads.* (Riv. Aeron., Vol. 16, No. 5, May, 1940, pp. 241-256.)
1112	Ferri, A.	*The Guidonia Supersonic Wind Tunnel.* (Atti di Guidonia, No. 15, 20/8/39.)

MISCELLANEOUS.

1039	Thum, A. ... ... Jacobi, H. R. ...	*Mechanical Strength of Phenol-Formaldehyde Synthetic Materials.* (V.D.I.-Forschungsheft, Vol. 10, No. 396, May-June, 1939, pp. 1-39.)
1113	Marino, A. ... ... Koch, R.	*Review of Radio Guidance and Landing Systems for Aircraft.* (L'Aerotecnica, Vol. 20, No. 3, March, 1940, pp. 167-196; No. 4, April, 1940, pp. 269-285.)

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LIST OF ABBREVIATIONS OF TITLES OF JOURNALS.

A.	Abstracts from the Scientific and Technical Press.
Aeron. Eng.	Aeronautical Engineering (U.S.S.R.).
Aer. Res. Inst. Tokyo ...	Aeronautical Research Institute of Tokyo.
Airc. Eng.	Aircraft Engineering
A.C.I.C.	Air Corps Information Circular.
Ann. d. Phys.	Annalen der Physik
Army Ord.	Army Ordnance.
Autom. Eng.	Automobile Engineer
Autom. Ind.	Automotive Industries.
Autom. Tech. Zeit.	Automobile Technische Zeitschrift.
Bell Tele. Pubs.	Bell Telephone Publications.
Bur. Stan. J. Res.	Bureau of Standards (U.S.A.) Journal of Research.
Chem. Absts.	Chemical Abstracts.
Chem. and Ind.	Chemistry and Industry.
Comp. Rend.	Comptes Rendus de L'Académie des Sciences.
Eng. Absts.	Engineering Absiracts.
E.N.S.A.	Revenue Technique de l'Association des Ingénieurs de l'Ecole Nationale Supérieure de L'Aéronautique.
Forschung	Forschung auf dem Gebiete des Ingenieurwesens.
Fuel	Fuel in Science and Practice.
H.F. Technik.	Hochfrequenztechnik und Electroakustik.
Ind. and Eng. Chem.	Industrial and Engineering Chemistry.
Ing.-Arch.	Ingenieur-Archiv.
Inst. Autom. Eng.	Institute of Automobile Engineers (Research and Standardisation Committee).
J. Aeron. Sci.	Journal of the Aeronautical Sciences.
J. App. Mech.	Journal of Applied Mechanics.
J. Am. Soc. Nav. Engs. ...	Journal of American Society of Naval Engineers.
J. Roy. Aero. Soc.	Journal of Royal Aeronautical Society.
J. Frank. Inst.	Journal of Franklin Institute.
J. Inst. Civ. Engs.	Journal of Institute of Civil Engineers.
J. Inst. Elec. Engs.	Journal of Institute of Electrical Engineers.
J. Inst. Petrol.	Journal of the Institute of Petroleum.
J. Met. Soc.	Journal of Meteorological Society.
J. Sci. Inst.	Journal of Scientific Instruments.
J.S.A.E.	Journal of Society of Automotive Engineers.
J. Soc. Chem. Ind. (Abstracts B)	Journal of the Society of Chemical Industry (British Chemical Abstracts B).
L'Aéron.	L'Aéronautique.
L.F.F.	Luftfahrt-Forschung.
Luschau.	Luftfahrt-Schrifttum des Ausiandes.
Met. Mag.	Meteorological Magazine.
Met. Prog.	Metal Progress.
N.A.C.A.	National Advisory Committee for Aeronautics (U.S.A.).
Phil. Mag.	Philosophical Magazine.
Phil. Trans. Roy. Soc. ...	Philosophical Transactions of the Royal Society.
Phys. Berichte.	Physikalische Berichte.
Phys. Zeit.	Physikalische Zeitschrift.
Proc. Camb. Phil. Soc. ...	Proceedings of Cambridge Philosophical Society.
Proc. Inst. Rad. Engs. ...	Proceedings of Institute of Radio Engineers.
Proc. Roy. Soc.	Proceedings of Royal Society.
Pub. Sci. et Tech.	Publications Scientifiques et Techniques du Ministère de l'Air.
Q.J. Roy. Met. Soc.	Quarterly Journal of the Royal Meteorological Society.
R. and M.	Reports and Memoranda of the Aeronautical Research Committee.
Rev. de l'Arm. de l'Air ...	Revue de l'Armée de l'Air.
Riv. Aeron.	Rivista Aeronautica.
Sci. Absts. (A. or B.) ...	Science Abstracts (A. or B.).
Sci. Am.	Scientific American.
Sci. Proc. Roy. Dublin Soc....	Scientific Proceedings of Royal Dublin Society.
Tech. Aéron.	La Technique Aéronautique.
Trans. A.S.M.E.	Transactions of the American Society of Mechanical Engineers.
Trans. C.A.H.I.	Transactions of the Central Aero-Hydrodynamical Institute, Moscow.
U.S. Nav. Inst. Proc. ...	U.S. Naval Institute Proceedings.
Verroffent (Siemens) ...	Verceffentlichungen aus dem Gebtete der Nachrichtenteegnik (Siemens).
W.R.H.	Werft Reederei Hafen.
W.T.M.	Wehrtechnische Monatschefte.
Z.A.M.M.	Zeitschrift für Angewandte Mathematik und Mechanik.
Z.G.S.S.	Zeitschrift für Das Gesamte Schiess und Sprengstoffwessen.
Z. Instrum.	Zeitschrift für Instrumentenkunde.
Z. Mech.	Zentralblatt für Mechanik.
Z. Metallk.	Zeitschrift für Metallkunde.
Z.V.D.I.	Zeitschrift des Vereines Deutscher Ingenieure.

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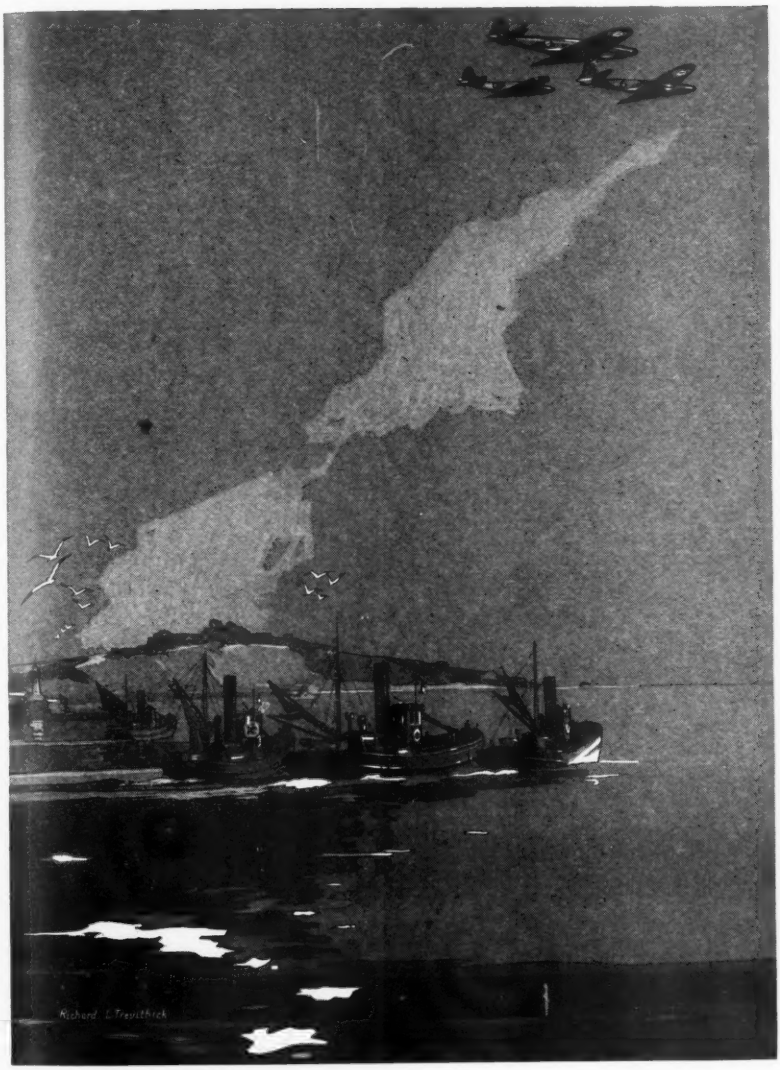

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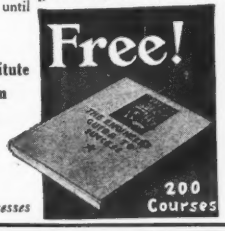

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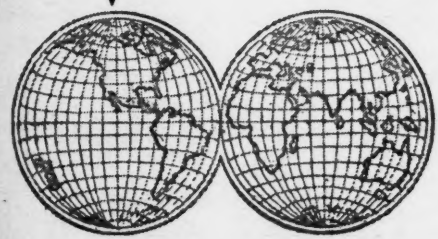

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